INVESTIGATING CROP DIVERSIFICATION AND LIVELIHOOD PATTERNS IN TWO IRRIGATION SYSTEMS OF RED RIVER DELTA, VIETNAM: A SIMULATION STUDY USING THE OLYMPE APPROACH

by

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Abstract

Livelihood and crop diversification are prominent features in the Red River Delta of Vietnam, where income from agricultural production is ranked in the top position.

The main purpose of this research is to investigate the key factors that make the difference between farmers' livelihood and cropping systems and to develop the best model of farmer's operation. The filed survey and farmer interview are conducted in two communes Hop Tien and Gia Xuyen, located in Bac Hung Hai and Nam Sach irrigation systems of Red River Delta.

Principal component analysis is applied to determine the main key factors in Gia Xuyen are: age of head farmer, family size, elevation of farm, cultivated land size, and intention for crop diversification and in Hop Tien are: expertise of farmer, number of farm labor in family, livestock style, rice yield and intention for crop diversification. The factors explain cropping system diversification in Gia Xuyen (cropping styles, location of farm, seedling used, herbicide used and potassium used) and Hop Tien (cropping system, intention about crop diversification, satisfaction with water supply condition, potassium used and location of farm.

Using typological approach and OLYMPE approach platform to develop the farmers' types and assess their performance. The farmer type is established according to main livelihood and cropping system. The results show farmer type II (full time farmer with aquaculture activities) performs the highest net income and the cropping system (rice, water melon, winter vegetable) gets highest income per one land density. Similarly, in Hop Tien the farmer type I2-4 (part time farmer gets commercial orientation with integrated production model of rice, water melon, animal and fish pond gives out the highest profit and the cropping system (rice, water melon, litchi) also get the highest profit per one land density. Three near future scenario about rice crisis, increase of fertilizer price and rice yield also are investigated to show the model get most sensitive rate: type I1_2 in Hop Tien with crops: squash, onion, longan, and model in Gia Xuyen (rice, soybean, onion) are influenced significantly with these changes.

The key factors suggest core issues in agricultural production; the local authorities should mind about the water supply situation and the diversification in production of farmers in Hop Tien and the fertilizer used, cropping styles in Gia Xuyen in planning strategies. From farmers' performances some suggestions are proposed as follows: Farmer in Gia Xuyen with cultivation model: rice, soybean, and special onion should change to other crops that gets higher profit and less influence by crisis like cropping style: rice, water melon, vegetables. And the farmers in Hop Tien should invest more to the integrated model of rice, onion, water melon, animal and fish pond. The experience exchange between farmers should be promoted. For managers training for farmer about production techniques, supply capital loan resources with low interest rate, fertilizer subsidy, new rice and vegetable variety should be invested. Besides that, training working skills, encouraging people do in industrial or service sectors in Hop Tien and the traditional handicraft in Gia Xuyen should be promoted. The timely research, forecast about market's demand should be conducted to inform to farmers. Infrastructures, irrigation systems are also should be invested more.

Further research about agriculture production in other regions should be conduct to investigate the best farmer's operation model and the research about impacts of input price, climate hazard to income in production should be conducted in the large scale.

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CHAPTER 1

INTRODUCTION

1.1 Background

Vietnam is one of the top rice exporting countries in the world. The agriculture of Vietnam is characterized by the integration of rice, maize, and cassava as main crops and livestock (poultry, buffaloes, cattle). Among these commodities, rice always takes the first place in agricultural sector. The rice production plays an indispensable role in the development of agriculture and rural Vietnam. Around 80 per cent in the total 11 million farmer households participating in rice production with the traditional cultivation methods. During the last three decades with the innovation in economic management mechanism the rice yield gets considerable improvement, not only to meet the national demand but also to export 3 to 4 million tons rice per year. The average rice yield is approximate 4.5 tons/ha.

With the development of society the demand for food increases, the natural calamity happens uncertainly and more frequently, the land and water resources becoming scarce. The challenges given out is the increase of yield, the guarantee of food security and exporting production remaining.

The agriculture has been undergoing continuous changes during the last three decades. The changes includes: institutional transformation, technical innovations, change in policy. The consequence of these changes is the significant rice yield increase. Besides that the modernization and upgrade of irrigation system also bring the significant changes in the development of agriculture.

The Red River and the Cuu Long River delta are two main granaries of Vietnam. The Red River Delta (RRD) is located in the North of Vietnam, covering a total area of 14,862.50 Km2 (account for 5 percent of total area of country) with population 18.2 million people (account for 22% the population of the country). This is area with traditional culture, high education level, the water resources structures has a long time period.

The irrigation systems in Red River almost are pumping stations with medium to large scale. Almost headwork of irrigation systems have been upgraded and restored, however, the modernization level of system is still low. Facing with the fact the irrigation system nowadays is seriously downgrading about the structure, the weakness in management and operation, the service capacity is quite low not meet the productive process.

The economic development of country associates with the industrialization and modernization period of the country. The Ministry of Agriculture and Rural development (MARD) attended to water resources development and management. From 2001 there have been many projects concentrated on researching about modernization in Water resources in Vietnam general, specifically in Red river.

The resolution of political bureau, N0 54-NQ/TW day 14, September, 2005, about economic-social development and national security, the security of Red river still to 2010, and orientation to 2020 have the objectives about concentration on investing, modernizing social-economic infrastructure to meet development demand, striving for basic targets become industrial region before 2020. The main mission about rural agriculture is investment to consolidate and upgrade the canal, dyke structure systems.

Figure 1.1 the Red River Delta position in the Map of Vietnam

1.2 Statement of Problem

In most Asian countries the agricultural sector is still keeping an important role for economic growth. Although they get an impressive achievement in rice production during the last decade, they are facing with problems of declining growth rate of rice yields and falling output prices in the world market. Therefore, policy objectives designed to boost the agricultural sector are: to achieve and maintain the food security.

One of the most important agricultural policies being adopted by most governments in Asian countries is diversification of the agricultural sector by promoting more profitable crops, livestock and non-farming activities.

At the end of 1980s, some of socialist countries collapsed, VN lost the market where supplied: materials, training executive and financial support. At that time industry and service sectors had negative growth, galloping inflation, serious economic crisis. At that time Vietnam government had the sound policy “khoan 10” about entrust land to each household. Together with the trade liberalization policy, exchange with foreign that the reason made an impression in economic growth to pull all the national economy. 10 year after, at the end of 1990s, the South-Asian countries fall down in financial crisis. Most market and the sources that supplied materials were in the Asian, so both service and industry those were affected significantly and fell down. The political bureau issued the decree VI that gets a package of policy about rural development, farmhouse and

agricultural expansion. The investment for agriculture increased two times, the jobless in service and industry changed to agricultural sector. Because of that timely change agriculture grew dramatically. One more time, agriculture contributes a humorous number to GDP and it helped the global economics overcome crisis.
The third, in 2008 when the global economic crisis happened, agriculture of Vietnam had dramatic growth (4.1% GDP). One more time the efforts in agricultural production helped VN resisted adverse effects of global economic crisis. Investment into agriculture sector is one priority of Vietnam government in the development of country. The agricultural diversification is one of resources to heighten farmer's income and contribute to poverty reduction.
The history in Vietnam proved agricultural sector is target for national economy when economic crisis happened. The growth of agricultural production connects to the diversification in production. The diversification of agricultural production concerns with the switch from rice to other crops, more rice on less land

In Vietnam, for a long period, concern with food self-sufficiency was determined by the war condition, poor transportation and inadequate food trading system. As a consequence, each province was supposed to do its utmost to be self-sufficiency in rice. This was highly uneconomical for provinces not well endowed for rice cultivation. Land and scarce resources were devoted to rice regardless of efficiency. Experiences indicate that food self-sufficiency at all cost is not the best way to resolve food problems. Models to utilize the comparative advantages of the country's various agro-ecological zones and to promote specialization and exchange of commodities need to be worked out.

One of the facts of Vietnam is the farmer households usually grow follow the immediate market demand without the long-term orientation. Knowledge on the local farming context, capabilities and strategies will contribute to build alternatives, solutions and proposals to help farmers to make the right decision at the right time. The use of "Olympe" aimed to improve farmers' understanding and provide orientations or policies for development institutions or donors.

1.3 Objective

The main objective of this study is to apply an integrated technical and economic approach (Olympe approach) to irrigation farming systems in order to set up a model of their operation and to run simulation and investigate future prospects on scenario-basis.

+ Specific objectives of this research are:

- To select, describe and assess two representative irrigation systems in the Red River with regard to the actual state of structure from headwork to tertiary canal, the irrigation technologies, and the actual organizational management task.

- To identify livelihood systems and farming systems in places and develop a model of farm operation using typological approach in selected area; to investigate dominant factors impacting upon diversification of livelihood.

- Apply the Olympe approach to farming types to highlight specific performance indicators and investigate effects of alternative technical and economic scenarios to production outputs.

- To draw conclusions and recommendation on policy and support for Red River Delta.

1.4 Scope and limitation of the study

- The data collection will be carried out in two irrigation systems in Red River basin.
- Using a participatory approach in order to validate scenarios and guarantee a high level of representative.
- The irrigation structures will be analyzed and assessed by field surveys.
- All the economic, institutional, technical aspects to be considered in assessing the irrigation systems.
- The data will be collected by field surveys, farmer's interview, and the available documents
- The OLYMPE software will be applied to test the alternative scenarios to bring out alternative choice for decision makers, farmers.

Limitation of the study

- Due to the small number of surveyed communes (two communes: Hop Tien and Gia Xuyen), the representative is more or less qualitative.

1.5 Expected outcome

- Describing and developing typologies of farming systems, assessing the livelihood diversification of households in two considered communes.

- Exposing the essence as well as determinants of livelihood diversification

- The economic indexes such as profit, profit per one unit of land, income and production expenses are calculated based on OLYME approach and the simulation for future scenarios by the rice crisis, fertilizer crisis and rice yield.

- To outline some recommendation and suggestions for farmers or decision makers in agricultural diversification development.

CHAPTER 2

REVIEW OF LITERATURE

2.1 A review of household typology

Household typology

As mentioned by Jary & Jary (1995) "*Any classification [conceptual] scheme. It may or may not be exhaustive within its empirical frame of reference. The role and utility of any typology is relative to the theoretical or practical perspective within which it is formulated*". In research on rural sociology the typologies to be used to discriminate between rural household about the social and economic characteristics (Whatmore, 1994). A typology is formed basing on grouping the households with the same characteristic about their actual practices and strategies.

Typology scheme can help us give out technical advices, assess the performance of farmer' group based on their exist operation. It also helps us find the recommendation for farm management. Typologies help the decision makers get the general picture about the diversity of socio-economic basis and also be useful for investment process in operation system. Farmer's type is formed based on farmers with the same feature about socio-economic foundation.

Schinitzberger (2005) points out that farming styles can show the interplay between economic situation, attitude and personality of farmer. He also investigated about the relationship between sustainable farming and farming style and he concludes that main factors have far better effect if they adjust to individual need in different region and predominant farming styles. Farming styles that show the integration of economic, objective and farmer's attitude can show the different ecological performance of farmer. The higher biodiversity associate with innovative and traditionalist farming and production-oriented farmers show the lowest biodiversification

Daskalopoulou, I., & Petrou, A. (2002) they investigate the ideal Greek farmer's type to potential adopters model of different farm enterprises and the research find out the survivalist is suitable. There are three farmer styles in Greek: **Subsistenc**e, **survivalist and productivist**. The finding of that research show that the subsistence farmer (type I) is corresponding to small farmers, hired labor and without modernization. Type II (survivalist) characterized by small medium farmer use off farm activities as complementary source of income and off-farm contribution to the mordenization of this farmer style. Meanwhile the productivity farming (type III) has characterized by large scale farmers and pursue full-time employment of farm household's member. Off-farm is related to higher level of mechanization, on the other hand it needs more capital investment.

The survivalist model depending on the combination of labor, capital and land. They found that the adoption of alternative farming activities is suitable with pathway of farm house type II. It means that the change of policy measure and institution framework This type is most suitable adjustment to changing policy and economic environment, which is supplemented importantly by off-farm activities.

2.2 A review of livelihood diversification

2.2.1 The concept of Livelihood diversification

The term "Livelihood" is to be used more popular than "job" or even "source of income". The definition of livelihood becoming more and more comprehensive related to sustainability. Chambers & Conway (1992) introduced a fully concept about livelihood as follows: "*A livelihood is sustainable when it can cope with and recover from stresses and shocks, and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base*"

Livelihood diversification appears as an indispensability of rural development and management towards resilience and sustainability. (Ellis, 2000: 298-299) showed that

"*Livelihood diversification is a pervasive and enduring characteristic of rural survival, reflecting the continuing vulnerability of rural livelihoods. The task of policy is to facilitate rather than inhibit diversity… Diverse livelihood systems are less vulnerable than undiversified ones*".

Following the opinion by Ellis (1998), livelihood diversification is a broad concept in terms of: property right, social and kinship networks, institutional support. Livelihood diversification is the process by the farmers making alternative activities, social support capabilities to heighten income and improve living standard.

One definition of income diversification that closes to original meaning of the word, refer to an increase in the number of sources of income or the balance between the different sources. A household with two sources of income would be more diversified than a household with just only one source, and a household with two income sources, each contributing half of the total, would be more diversified than a household with two sources, one that accounts for 90 percent of the total (Joshi et al, 2002; Ersado, 2003)

The other definition of diversification is the shift from subsistance food production to commercial agriculture. It does not mean to have to increase in the balance of income sources, it also may be the change from grains, tubers and vegetables for own consumption to specializing in one or few cash crops. (Delgado & Siamwalla, 1997, 13- farm diversification)

The third, income diversification refer to the expansion in the importance of non-crop or non-farm income. Non-farm income includes both off-farm wage labor and non-farm self employment (Reardon 1997, Escobal 2001). Income diversification includes increase of number and/or the balance of income sources. Except the case when the share of nonfarm sources from 30 to 75 percent, it presents diversification into non-farm activities but not in term of the number or balance of income sources.

In the national level, income diversification refers to the structural transformation, it is long-term decline in the percentage contribution of agricultural sector to GDP (Gross domestic product) and employment in growing economies.

Finally, income diversification is also defined as a process of switching from low value crops to higher value crops, livestock and non farm activities. (refers to high economic returns per one **unit of land or labor**)

Diversification is definition as a source of income growth and a potential mean of poverty reduction. It is in term of the increase or balance number of income sources. Diversification from staple crop production into high-value activities.

According to Goletti, F (1999), the acceleration of growth and income in rural areas in the future will have to come from non-rice agricultural commodities and rural non-farm activities. On the other hand, successful diversification requires a commercialized agricultural system, adequate infrastructure development and well function rural institutions.

Income Diversification in Vietnam

As one survey about Living Standard that conducted in 1992-1993, Pederson & Annou (1999) investigated that in Vietnam the livelihood diversification related to small household (farmers), they have higher educational level and non-rice output in agricultural production or non-farm activities.

2.2.2 A review of livelihood diversification

a) Determinants of diversification

First, the multiple income sources are one strategy to reduce risks of weather and other factors. Second, the diversified households bring out total income greater than the specialized. For instance production from livestock can provide animal traction and manure to increase crop production. The third factor multiple income sources is a useful adaptation to missing or poorly functioning markets. Fourth, income diversification explains non-farm activities and seasonal participation in agriculture during the harvest season of major cash crop. Fifth, heterogeneity in employment opportunities of household member is one motivation of diversification. Finally, the combination of diverse consumption needs and high transaction costs in purchasing consumer goods can motivate diverse income sources.

b) The relationship between Livelihood diversification and sustainability

Sustainability is a concept including a number of disciplines, multi-dimensions about biophysical, economic and socio dimensions (Roling, 2003) and applied at levels of aggregation (Pearson, 2003). In accordance with livelihood perspective: Sustainability is achieved when the livelihood can cope with and recover from stresses and shocks, maintains or improvement its capabilities and assets now and in the future, without undermining the natural resource base. (Carney, 1984:4)

Meanwhile, protection against stresses and shocks is greater in diverse than undiverse livelihood systems (Ellis, 2000b). Block and Webb (2001) believe that livelihood diversification is one important pathway towards sustainability.

As in report of Kinsey et al (1998) income diversification and ability to withstand shocks particularly in terms of consumption smoothing have a positive association. Similarly, in the viewpoint of Dorward et al. (2001) livelihood diversification contains consumption smoothing, risk management and production functions.

Furthermore, non-farm income can be invested in agriculture or used as collateral to facilitate access to credit for a sustainable agricultural intensification. (Reardon et al.,

1994). Grabowski, 1995 showed that livelihood diversification reduces risks associated with innovation that can encourage adoption of technologies contributing to sustainable agricultural intensification.

L.Zhen and J.K.Routray (2003) recapitulated some sustainability indicators that measuring the agricultural sustainability as follows

Table 2.1 Operation indicators for determining agricultural Sustainability

Indicators	**Elements**
Economic	- Crop productivity - Benefit-cost ratio of production - Net farm income - Per capita food grain production
Ecological	- Amount of fertilizers and pesticides used - Irrigation water used - Soil nutrient content - Water use efficiency - Depth to the groundwater table - Quality of groundwater for irrigation - Nitrate content of both groundwater and crops
Social	- Food self-sufficiency - Equality in food and income distribution among farmers - Access to resources and support services - Farmers' knowledge and awareness of resource conservation

c) A review of livelihood diversification in the World and Vietnam.

According to the research by Delgado and Siamwalla (1997) about income diversification in Asia and Africa. They showed that African farmers often have highly diversified crop mixes as a strategy to reduce risks associated with bad weather. Whereas, in many Asian countries, crop diversification is associated with reducing the importance of rice and moving toward fruits, vegetables, and livestock activities. This will increase income but farmers must face market risks, particularly when the commodity is perishable. Then, governments can play a constructive role in facilitating institutions, such as cooperatives and contract farming that facilitate diversification into high-value commodities, thus raising rural income.

The research in West Punjab of India considered long-term trends in agricultural production over the 20th century (Kurosaki, 2003). The result showed that the diversification, here was the reallocation of land toward higher-yielding crops. In the first period, rice yield growth get from concentration of rice production in the districts with higher growing yields, while in the second period, it was due to higher yields in each district. Finally, analysis across districts indicates that road density is associated with diversification in the first period and with specialization in the second period (Kurosaki, 2003).

In Peru, non-farm activities contribute roundly 50 percent total income to rural households. Income from non-farm enterprises is positively correlated with education, electrification, proximity to market, and the value of crop output per hectare (Escobal, 2001). In Zimbabwe, Ersado (2003) found out that in rural areas, richer households had more diversified income sources, while in urban areas the reverse was true.

One study about comparison of diversification between Rwanda, Kenya, and Cote d'Ivoire showed that in these regions with low rain and poor soils the diversify is away from crop production. Though, unskilled labor income is associated with poor households, most other forms of non-farm income are positively correlated with income.

About diversification in Vietnam, Pederson and Annou (1999) used the 1992-1993 Vietnam Living Standards Survey to examine the patterns of diversification. They found that agricultural diversification is associated with small farms, small irrigated areas, and high levels of education. Besides, with households whose crop production is relatively specialized in rice tend to have more non-farm income diversification. This suggests that households will get income from non-rice production or non-farm activities.

Henin (2002) depicted diversification patterns in the Northern Uplands, focusing on Lang Son province. This research showed that "Doi moi" policies in 1986 have increased income and stimulated income diversification. In the study area farmers have adopted modern rice varieties and fertilizer together with local varieties and have expanded production of cash crops (sugarcane, soybeans, tea, peanuts, tobacco). Non-agricultural activities bring out income including: collecting firewood, bicycle and motorbike repair, and so on.

A study of Alther et al, (2002) in Ba Be District highlights the importance of accessibility in determining income opportunities. In remote regions, farmers mainly rely on subsistence crop and livestock production. They have fewer opportunities to sell their output, benefit from government programs, or obtain non-farm employment. As consequence, they tend to

be poorer than villages on main roads close to urban centers, even if they have irrigated lowlands.

Fatoux et al, 2002, with one study in Cho Moi District showed that policy about allocation of land has been successful in stimulating intensification of lowland rice production, diversification in the uplands, and preservation of forestland. Intensification of lowland production has produced the liquidity and food security needed to allow households to diversify on upland plots.

Farmers also realize that there are a number of constraints to diversification and poverty reduction: lack of capital, shortage of paddy land, poor access to markets, poor irrigation infrastructure, and low quality education.

A recent book contains detailed studies about changes in land use and income sources in Bac Kan Province (Castella and Dang Dinh Quang, 2002). Most studies provide a long-term perspectives, describing changes in land-use patterns as a result of various changes in policy and technology: collectivization in the late 1950s, the introduction of high-yielding rice varieties in the late 1960s, the contract system under Decree 100 in 1981, de-collectivization of land in the years following Resolution 10 of 1988, and the Land Law of 1993, which began the process of allocating land-use certificates.

During two last decades Vietnam is making progress in agricultural diversification. It is necessary to develop the capabilities of farmers to have flexible adjustment by diversifying, whether horizontally across products or vertically into different aspects of adding value. Diversification characteristics depend on distinctive agro-ecological and economic conditions, and not all regions are diversifying with comparable success. The Mekong and Red River deltas are two main rice producing areas of Vietnam where most of the poor live, are the least diversified. Accelerating agricultural diversification will require a package of efforts tailored to the different production systems. Strengthening agricultural support services is critical across these systems, encompassing research and extension, agricultural technology, food safety, vocational training and information dissemination. Expanded access to financial services will be important, as will further improvements of the quality of trade infrastructure related to supply chains for new inputs and non-traditional product lines.

2.3 Agriculture in the Red river Delta

Country background

Vietnam's food supply is critically dependent on irrigated agriculture. About 80% of the 4 million hectares of cultivated paddy have some form of irrigation, although the area effectively irrigated is probably just over 2 million ha due to incomplete systems, planning and design inefficiencies, and poor operation and management. With population growth, Vietnam's food requirements are expected to double by 2030. However, the current standard of operation, management and institutional arrangement for irrigation and drainage in Vietnam is inadequate to meet the challenge of such a large increase in food output.

The economic reform “Doi Moi” in Vietnam from 1986 has greatly contributed to agricultural development of Red River Delta, which is reviewed from the viewpoint of water management, land use, and rice production. Farmers are encouraged to invest more

input in the cultivated land. Water management systems was improved, land use was intensified and diversified.

One of the most important strategies for agricultural development in Vietnam is the growth in productivity, but in land-constrained region such as Red River Delta it is not easy to achieve successfully. The level of crop intensification is already high together with the land competition from infrastructure development, industrialization, urbanization. The immediate challenges are the yield increase, crop diversification livelihood diversification to the sustainable agricultural development, especially, when Vietnam is a member of WTO.

The agricultural system bases on high productivity will help farmers raise income, increase their living standards, break out poverty. Farmers need a sufficient degree of freedom to be able to choose different ways to improve their lives. Therefore, one of the important options is the diversification of livelihood.

Red River Delta (RRD)

The RRD is the second biggest river in Vietnam that is a typical area for diversification and sustainable development in agriculture. Rice is still the main crop in this region with cultivation twice per year and winter crops for possible regions. Paddy production represents 22 % of Vietnamese whole paddy production. The research results in this delta have broad application for other regions. In this study two representative irrigation systems in delta to be considered ensured these characteristics:

+ They can represent for other irrigation systems in the basin, for comparison and diversity purposes

+ They give access for data collection, easy for conduct surveys, enthusiastic response of farming households

+ There has been diversification, different farming types.

+ They are typical areas for PIM, IMT in Vietnam.

Description of Red river delta

The Red River runs through China, Lao, Vietnam and finally merges into the East Sea. The average total surface water is 133.68 billion m3 and the volume inside Vietnam is 81.86 billion m3 (make up 61.2%). This is area with sufficient water resources and high potential about agriculture. From the policy “Doi Moi” in 1986, the production from agriculture has developed significantly. Farmers have been encouraged to invest more input into cultivated land. The development of agriculture has been reviewed from viewpoint of water management, land use, and rice production.

The RRD is an age-old settlement area reclaimed to grow rice over 2000 years (Sakurai, n.d.). With fully characteristics of tropical climate region concern to strong floods in summer as well as monsoon typhoons and droughts. To protect the life, minimize adverse impacts of calamities and provide water to paddy fields people here constructed water control works such as canals, dyke more then 8 centuries ago (Chassigneux, 1912). Moreover, the traditional to modern irrigation methods has also been introduced from more than 7 centuries to intensify paddy agriculture.

From 1960s North Vietnamese State had policy about collectivization of agriculture in there concentrated on mechanized drainage and irrigation, in order to modernize agricultural system? Large scale irrigation and drainage schemes and pumping stations were built. In addition new paddy varieties and chemical fertilizer use also to be introduced to farmers to intensify agriculture.

The RRD divides into two parts: the North Delta and the Midland and North mountain area with following characteristics

Table 2.2 The characteristics of regions in RRD

Regions / Characteristics	**Midland and north mountain area**	**North Delta**
Total natural area (ha)	10,045,853	1,478,400
Agricultural land (ha)	1,305,050	857,515
Annual tree land (ha)	979,288	723,240
Rice and subsidiary land (ha)	433, 363	
Population (people)	11,349,000	17,240,000
Hydraulic works	+ 1,750 medium and small reservoirs + 40,190 weirs + 379 electric pumping stations + Total design irrigation area is 263,067 ha + Actually irrigated area is 206,037 ha.	+ 55 large and medium irrigation and drainage schemes with headwords, pumping stations, intakes and outtakes + 500 sluices under dykes for water supply and drainage + 1700 electric pumping stations + 35 reservoirs (storage from 0.5 – 230 million m3) + The existing irrigation coefficient of all schemes is 0.7 to 0.9 l/s ha +Drainage coefficient from 3.0 to 4.0 l/s ha

2.4 Principal component Analysis (PCA)

Definition: Principal component analysis is a mathematical procedure that transforms a number of correlated variables into a smaller number of uncorrelated variables (called principal components or domain components).

The first principal component accounts for as much of the remaining variability as possible. Traditionally, principal component analysis is performed on a square symmetric matrix of type SSCP (pure sums of squares and cross products), covariance (scaled sums of squares and cross products), or correlation. The mathematical technique used in PCA is eigen analysis. Basic goal of PCA is to reduce dimension of data.

Application of PCA

As research by Astel et al (2004), they used PCA to achieve interrelationships between the measured variables in two seasons (winter and summer) and two categories of precipitation volume in the Tricity region.

Andrew et al (2003) applied PCA for assessing the soil quality on farm in California. The result showed the significant variables that determine soil quality index

2.5 Introduction OLYMPE software

Olympe a decision support system to improve collective decision

The Olympe software (Attonaty et al., 2005) is a simulation tool that can integrate both economic and technical aspects (e.g. crop management) of farm operations and externalities (e.g. nitrate leaching). This software helps decision making in strategic orientation of agricultural farms on the individual scale as well as in a collective methodology. It allows us:

- Obtaining a database on operating systems;
- Evaluating the consequences of new investment, adding input/output per crop, changes in crop schedule, crop management;
- Entering unknown factors in the simulation and to evaluate the consequences of unforeseen events for the project results (price fluctuations, climate factors, changing in market trends)

The Olympe software allows groups of farms to be constructed by a matrix made of the number of farmers classified as one type. The simulator acts by highlighting the impact of changes on the crops or management methods but does not allow the strategies and courses of action of the various stakeholders to be represented. In order to model the complete operation of the system, it is important to understand and formalize the stakeholders' rules for decision-making as well as the laws that govern these rules. Olympe was designed to work interactively with farmers, either individually or as a group (Le Grusse et al., 2006).

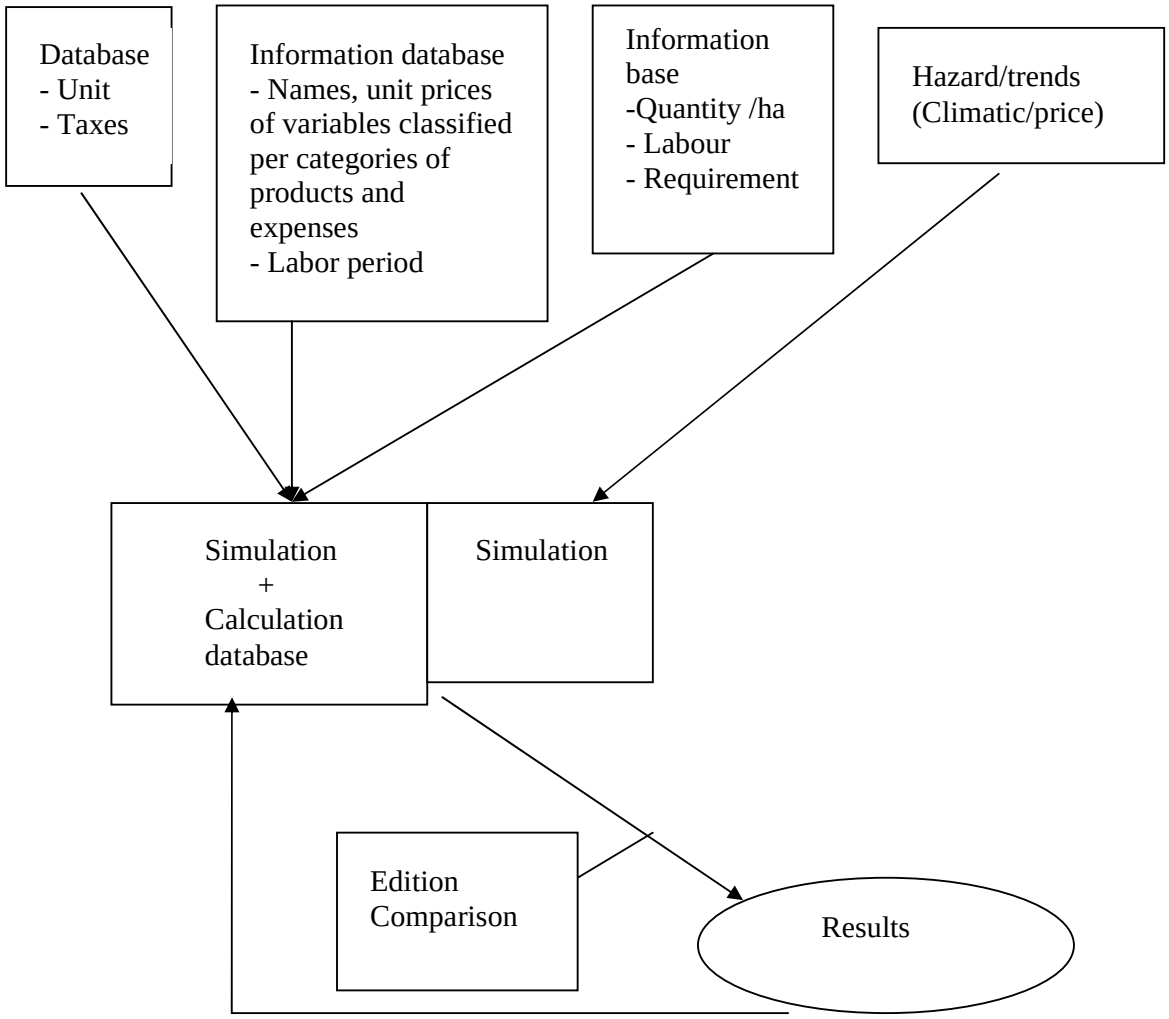


Figure 2.1 OLYMPE - The conceptual model (From Penot, 2007)

CHAPTER 3

METHODOLOGY

3.1 Methodological approach

The main purpose of this study is to describe the current situation of two representative irrigation systems in Red River Delta in terms of technical, economical, social respects, and to develop the farming typologies, using OLYMPE software to test alternative scenarios. The major steps will be as following:

- Collecting the data about socio-economic and technical aspects of households and schemes to build and form farming typologies. The data gets by mainly basing on field survey combining with reviewing and inheriting the literature, material and previous documents.

- Participatory Rural Appraisal, synthetic analysis and assessment about actual situation of irrigation systems of RRD.

- Capturing data into the OLYMPE software, which simulates the different scenarios, the consequence of the technical change, possible events, such as fluctuation of prices, climate hazard and market evolution.

- Famer interviewer, short and long questionaire and farmer group discussion to give out alternative scenarios.

- Comparing some sustainability indicators from actual context and given scenarios by farmers participaton and that achieved by testing OLYMPE software since then suppose some recommendations about farming systems management.

3.2 Overview of study area

3.2.1 General information

The research is conducted in Hai Duong province, which is located in the center of Red River Delta. It covers a total area of 166,078 ha and composes of 10 districts with an administrative center of the province.

Hai Duong is the main point economic region of Red River Delta together with Ha Noi, Hai Phong, Quang Ninh constitute economic pivot of North Vietnam. The administrative center of this province is 58 km far from Ha Noi to the East. Its geographical bounds are from $20^0 36'$ to $21^0 15'$ North latitude, $105^0 53'$ to $100^0 30'$ East longitude.

Fig 3.1 Location of Hai Duong province in the map of Vietnam

3.2.2 Topography

The topography is quite flat, only a small of part with hills and mountains in Chi Linh and Kinh Mon district, it slopes from northwest to southeast.

3.2.3 Climate

With the tropical monsoon climate, it divides into distinct two seasons: rainy (from May- September) and dry season (October to April). The meteorological data of Hai Duong measured in Hai Duong station. The annual average temperature is 23.3^{0}C and the annual average rainfall is 1300 - 1700mm.

The large rainfall events usually happen from May to October.

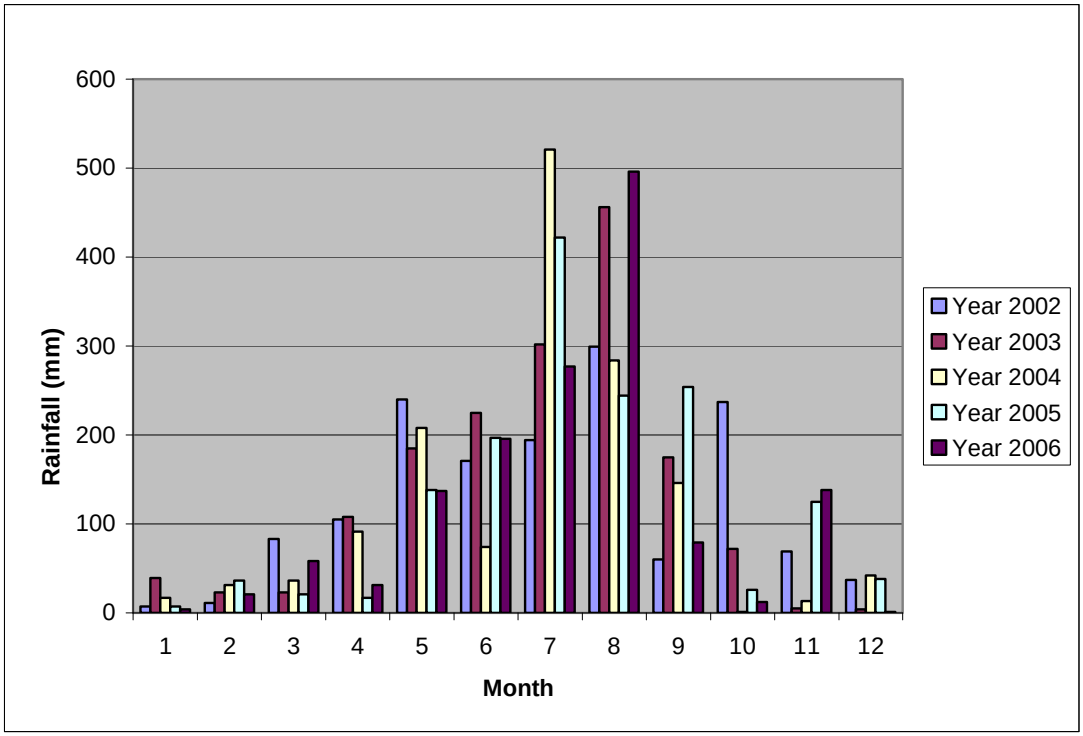


Fig 3.2 Comparison between the monthly average rainfalls of years from 2002 to 2006 in Hai Duong province

(S*ource: Hai Duong statistical yearbook, 2006)*

3.2.4 Hydrology and water available

The network of rivers run through this province including: Red River, Thai Binh river, Luoc river, Kinh Thay river. Abundant water resource is one of conditions to impulse agricultural development here.

3.2.5 Demography

Total population of this province is 1,722.394 thousand habitants (approximately 1.7 million people) (2006) of which 80% are rural. The population density is 1,043 persons/km^2)

Population structure

Table 3.1 Classification of population structure in Hai Duong province, 2006

Age groups	**Percentage (%)**				
	Total	**by sex**		**by Region**	
		Male	Female	Urban	Rural
<= 14 years old	23.5	25.2	22	23.2	23.7
15-60	64.8	65	64.5	66.4	64.5
>= 60	11.7	9.8	13.5	10.4	11.8
Total	100	100	100	100	100

(*Source: Hai Duong statistical yearbook, 2007)*

As can be seen percentage of population in labor age (from 15 to 60 years old) takes 64.8% in total population of province, of which the percentage of male is bigger than female and they live in urban more than in rural area (66.4% compares with 64.5%). This shows that this province has high potentiality in economic development with profuse labor force and preferential natural condition.

3.2.6 Agriculture production

Hai Duong develops gradually high quality agriculture, clean agricultural product, applying advanced technology into production. Production not only supplies to this province market but also foster to Ha Noi capital market.

Total agricultural land is 102,548 ha with rice as main crop. Spring rice occupies 71.780 ha; meanwhile, summer rice is 70,637 ha. The rice yield in spring season is 6.1 tons/ha which is higher than in summer with 5.5 tons/ha.

Table 3.2: Crop Area and average yield of Hai Duong province in 2007

Crop	Crop Area(ha)	Yield (t/ha)	Irrigation Area (ha)
Spring Rice	71,780	6.081	64,709
Summer Rice	70,637	5.501	62,939
Others crop (upland crops)	55,379		33,241
Maize		3.975	
Soybean		1.271	

(*Source: Hai Duong statistical yearbook, 2007)*

3.2.7 Irrigation systems in Hai Duong Province

Basing on topography feature, hydraulic structure in Hai Duong divided into two sectors: Bac Hung Hai area and tidal area.

Table 3.3 Irrigation areas of Hai Duong province

Area	Irrigated area	Total natural area (ha)	Cultivated area	Classification according to elevation
Bac Hung Hai	Cam Giang, Binh Giang, Gia Loc, Tu ky, Ninh Giang, Thanh Mien and Hai Duong city	80,092.82	46,699.26	< 1,0 has 2,793 ha > 1,0 to 1,5 : 12,070 ha > 1.5 : 28,260.26 ha The land with elevation < 1.5 m easy get flooded when heavy rainfalls occur
Tidal zone	Chi Linh	28,189.78	13,330.1	1,450 ha (elevation < 1.5 m)
	Kinh Mon	16,349.04	8,795.33	1,710 ha (elevation < 1.5 m)
	Kim Thanh	11,364.88	6,983.02	1,405 ha (elevation < 1.5 m)
	Nam Sach	13,280.04	7,631.14	
	Thanh Ha	15,908.74	9,472.23	

(Source: Irrigation department of Hai Duong province, 2008)

Two irrigation systems were selected for study are Bac Hung Hai and Nam Sach irrigation systems. Nam Sach system located in integral Hai Duong province, meanwhile, Bac Hung Hai irrigation is the biggest irrigation system of Red River Delta. Bac Hung Hai covers irrigated area of 4 provinces: Ha Noi, Hai Duong, Hung Yen and Bac Ninh.

Two irrigation systems selected in this province because of these reasons:

+ It is easy to collect data, the cooperation between authority and farmer works quite well

+ The high crop diversification

+ This is the typical region in food production in Red River Delta

+ Applying successfully advanced technology so this province toward the sustainable agriculture, high quality production for exporting.

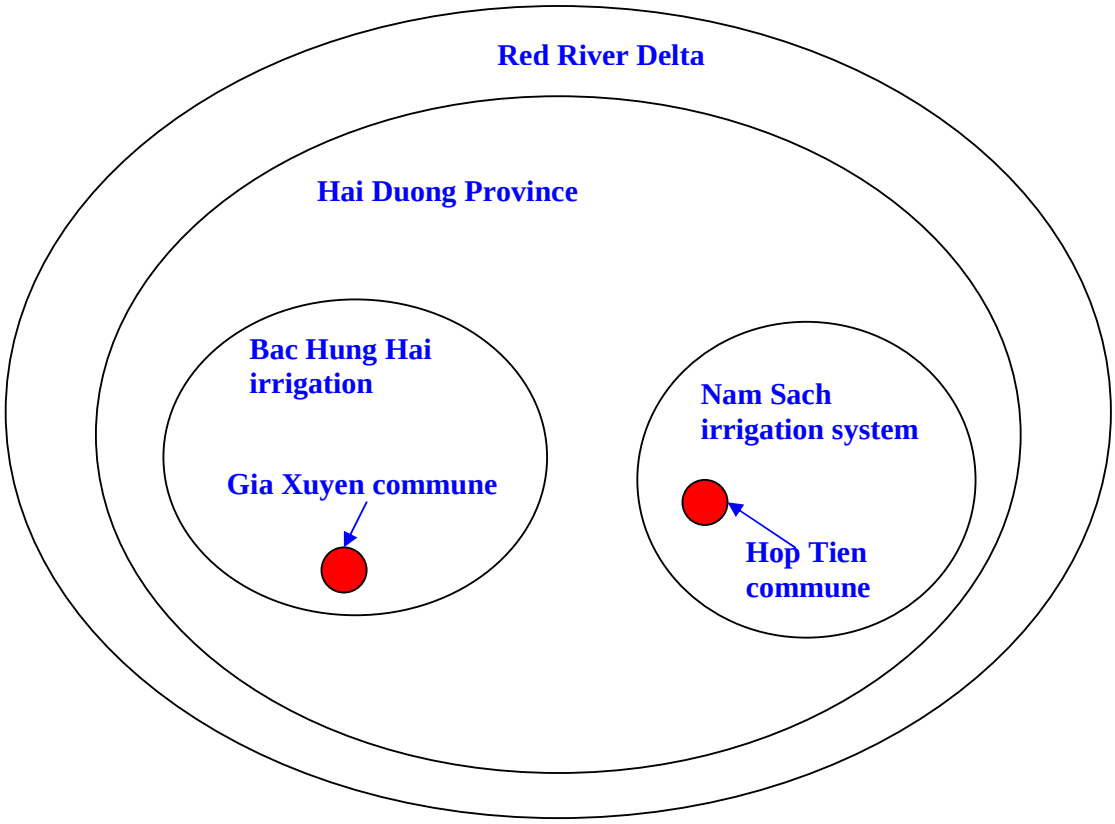


Fig 3.3: Schematic overview of case study systems

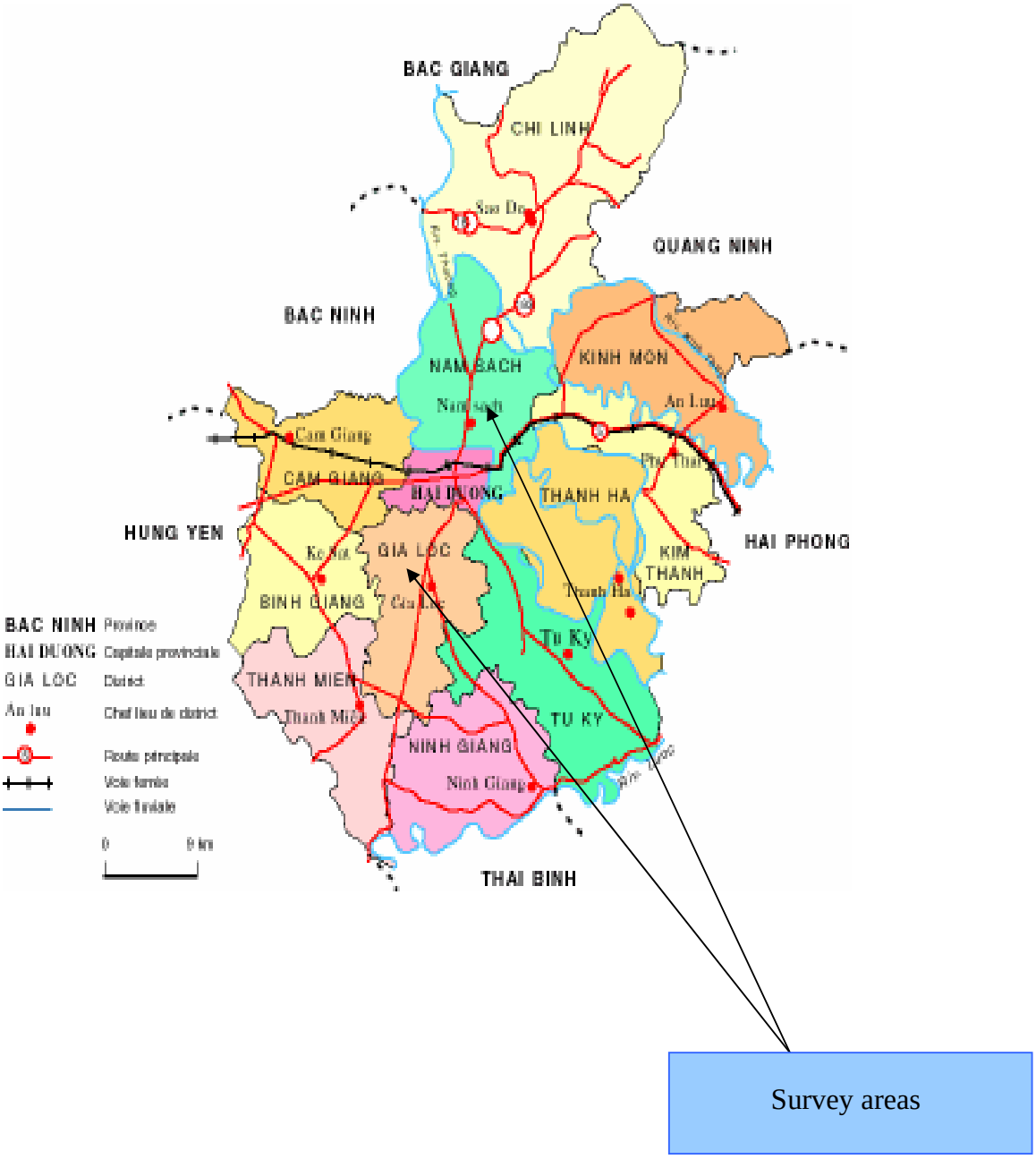


Fig 3.4: Study areas

3.3 Case study

3.3.1 Bac Hung Hai (BHH) irrigation system and Gia Xuyen commune

The Bac Hung Hai (BHH) irrigation system has been built from 1958. It services water irrigation for Hung Yen, Hai Duong, apart of Bac Ninh and Ha Noi, it lies among the Red river (Western), Duong river (Northern), Thai Binh river (eastern) and Luoc river (Southern). In the longitude $105^0$50 - $106^0$36, latitude $20^0$30 - $21^0$07. The Bac Hung Hai system has quadrilateral form with each dimension around 50-70 km, the total area is 2002,3 km^2 , dense population and a great number of urban and industrial zone. This is the

biggest irrigation system of the Red river Delta with total irrigated area is 52.000ha and drainage 180.000 ha. In Hai Duong province, BHH covers irrigated area of seven districts: Cam Giang, Binh Giang, Thanh Mien, Gia Loc, Tu Ky, Ninh Giang and Hai Duong city. We choose Gia Xuyen commune in Gia Loc district as one typical commune for field survey.

Figure 3.5 Bac Hung Hai irrigation system

(Source: http://www.vncold.vn/Web/Content.aspx?distid=713)

The water for irrigation to be taken from Red river through Xuan Quan inlet sluice (the width: 19m; 4 bays and discharge 75m3/s). The drainage water flows through Cau Xe, An Tho drain.

Figure 3.6 Xuan Quan Inlet sluice (Văn Giang, Hưng Yên)

3.3.2 Gia Xuyen commune

Gia Xuyen is a commune with agriculture production is main job, especially developed in cultivation. Land turnover is quite high with five crops per year. Reasonable crop structure and intensive cultivation are the basis of sustainable development in this commune. Gia Xuyen has highway 17 runs though; this commune lies in propitious location for economic exchange, goods, and has open condition with advance science and technology.

a. Natural condition

The land in Gia Xuyen is relatively high but not flat, varies from 2.5 m in the West to about 1.3 m in the East. Typology of this commune slopes from North to South. It has tropical monsoon climate of Red River Delta with two seasons: rainy season from May to October and dry season from November to April next year. The total rainfall in the rainy season is approximate 1,190 mm. Heavy rains usually concentrate on several days when low barometric pressure occurs, for instance from 20th to 24th, July, 2004 the accumulative rainfall reach until 445 mm.

For dry season, the temperature is quite low. Gia Xuyen commune has 492.09 ha total area, of which 318.63 ha agricultural land, 173.46 ha is non-agricultural land

b. Social situation

There are 7,922 people in Gia Xuyen commune, divided in 2,100 households. Among them, 7,195 persons (account for 90.8% of total population) in 2,085 households have agricultural lands.

The agricultural households divided into 9 agricultural production teams (APT) with brief description as in following table

Table 3.4 The agricultural production teams in Gia Xuyen commune

No	Population	Numbering of households	Equivalent labor units	Area (m^2)
1	835	229	386	307,173
2	813	283	318	257,426
3	700	218	267	268,804
4	747	236	399	264,444
5	689	200	540	305,185
6	643	202	238	288,365
7	943	216	340	387,610
8	881	275	480	373,608
9	944	226	523	350,244
Total	7,195	2,085	3,491	2,802,859

As can be seen the number of people in each team varies from 643 to 944 persons, households from 200 to 283 households and cultivated area from 257,426 to 387,610 m^2. It shows that agricultural households although agriculture is main economic activity, the land they hold is quite low. In average, each household with 3.45 persons and 1.67 labors has only 1344 m^2.

Labor structure and population has decreased because of emigrant and people, who go abroad to work or changing to work in industry, services.

d. Irrigation system in Gia Xuyen

The irrigation system in Gia Xuyen commune takes water by Quan Phan pumping station, water conveyed through two irrigation canals: Dong Trang and Doan Thuong to supply water to the field in Gia Xuyen commune. Total irrigated area in Gia Xuyen is 194 ha.

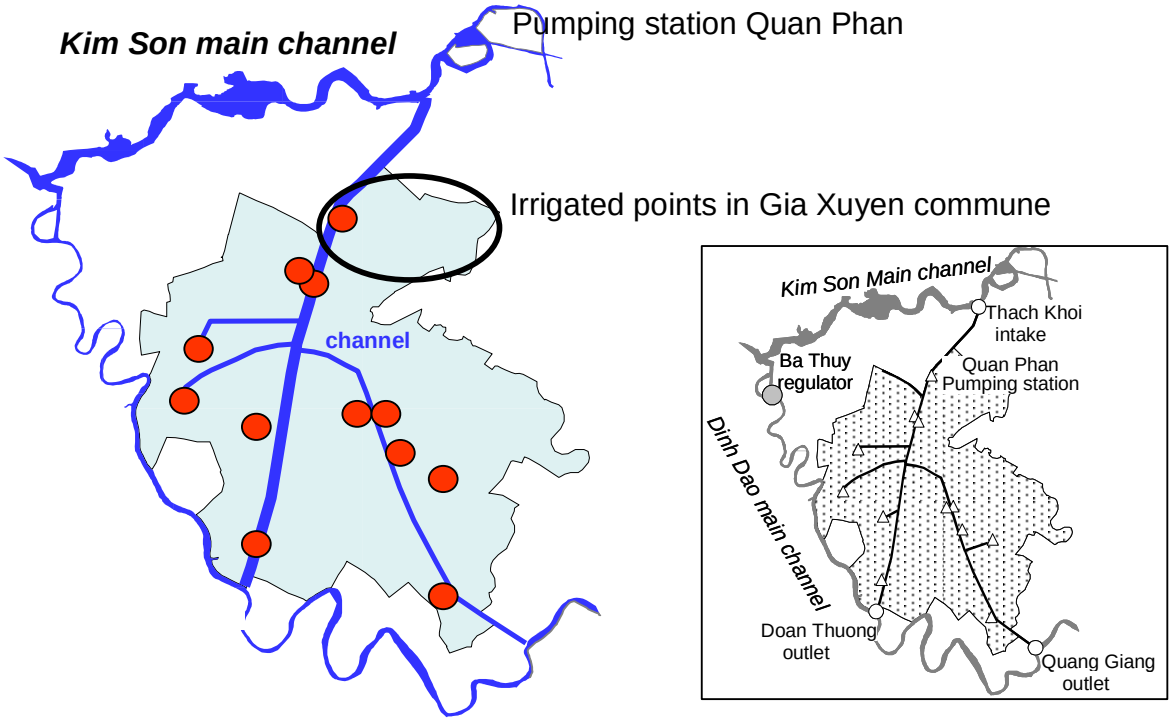


Fig 3.7 Outline of irrigation system in Gia Xuyen commune

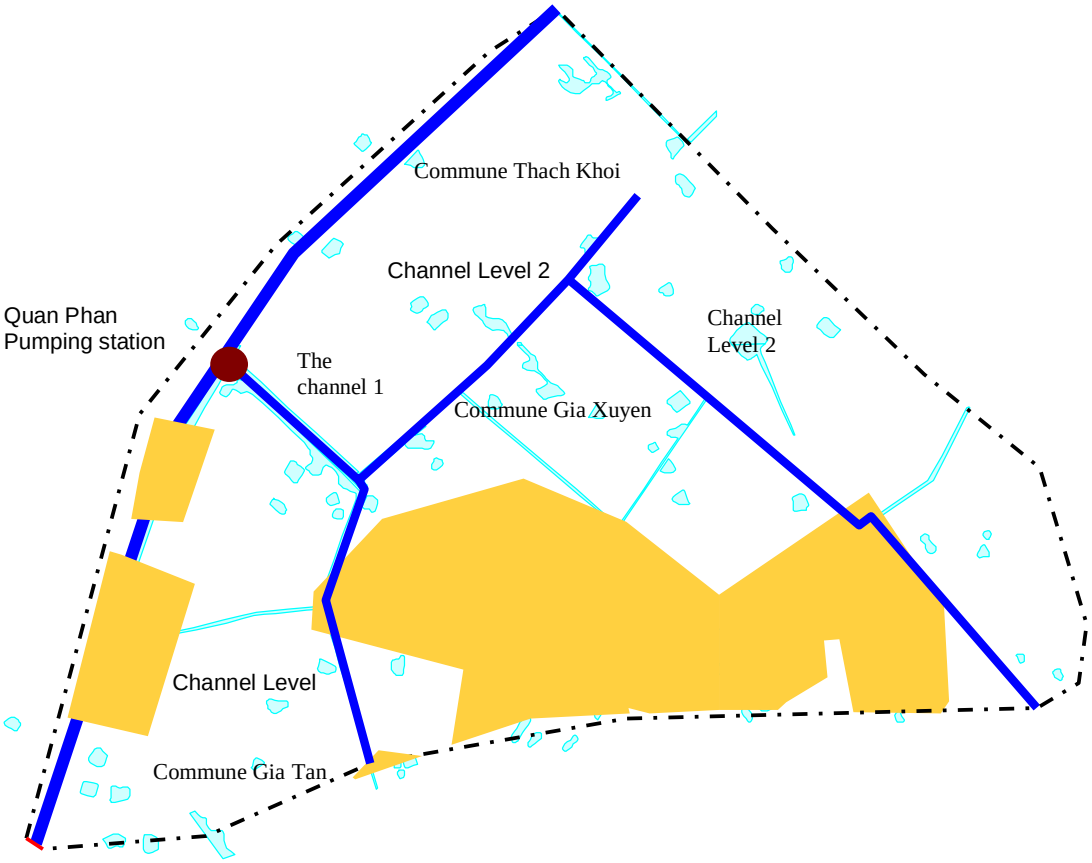
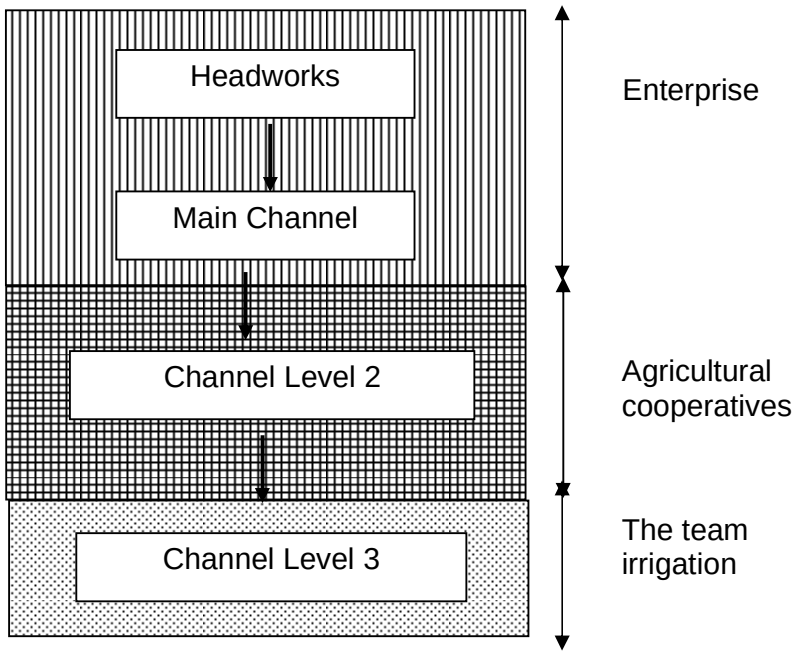


Fig 3.8 Map of irrigated area in Gia Xuyen

Fig 3.9 Management organization of Bac Hung Hai system
(Part-level management)



Institutional arrangements

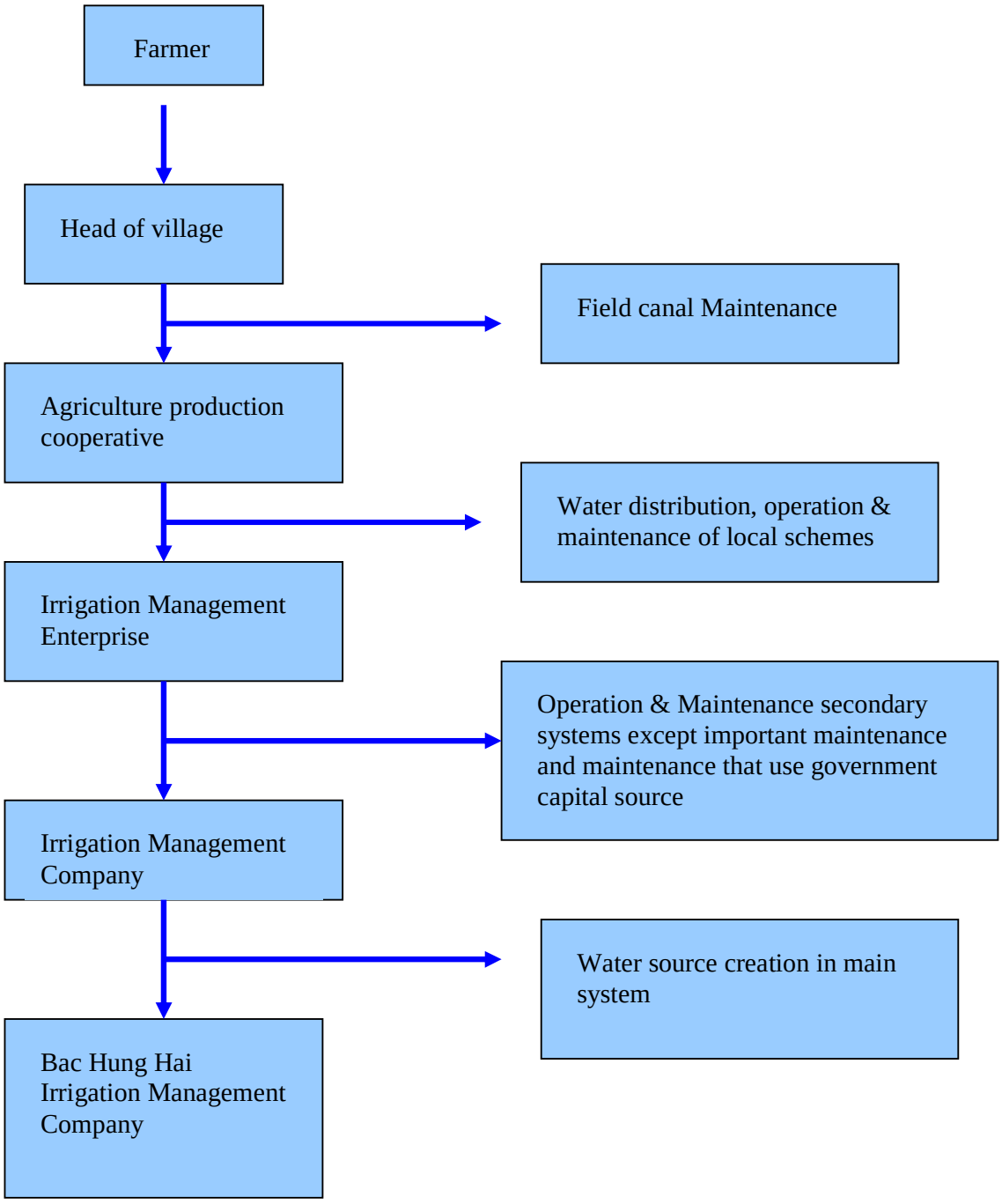


Fig 3.10 Organization for water fee collection and fee use of Bac Hung Hai irrigation system

(*Note: Vertical arrow* ↓ *Collecting fee;*

Horizontal arrow → *Use of water fee and function performed)*

Organization for water fee collection

After collecting water and farmer's contribution from farmers, the head of village keeps the second part to carry out maintenance works of field canals and submit the first to APC.

Agriculture production cooperative (APC) keeps his share for water distribution in irrigated area and for O&M activity of local irrigation system and submit the rest to Irrigation management Enterprise (IME).

Above mentioned payments are carried out through economical contracts signing between APC and IME in one hand and between Irrigation management company and Bac Hung Hai irrigation system company in other hand three times a year.

3.3.3 Nam Sach irrigation system and Hop Tien commune

Nam Sach is one of irrigation systems located in tidal region. Total natural area of this system is 13,280.04 ha, of which cultivated land are 7,631.14 ha. The biggest resource supplies water to this system is Huong River with 1,550 ha. The rest parts take water from Thai Binh, Thay River through Ngo Dong, Hiep Cat, Ngoc Tri, Thuong Dat gates.

For drainage all water from this system drainage to Thai Binh, Rang and Thay River though gates: Ngoc Tri, Chu Dau, Do Han, Nam Dong, Do Phan and so on. All area in Hop Tien commune irrigated by Nam Sach system.

3.3.4 Hop Tien commune

Hop Tien is located in the North of Nam Sach district, Hai Duong province. It is bounded by Thanh Quang commune in the East, Hiep Cat commune in the West, Quoc Tuan and Nam Chinh in the South, Nam Hung and Nam Tan in the North. With flat topography and annual rainfall about 1500-1600mm, this district is the main rice growing region in the Red River Delta.

The agricultural land in Hop Tien is 376.26 ha takes 59% of total area is 643.04 ha. Its population is 7,416 persons, of which working-age population is 35% (equal 2,595 persons). There are 5 villages with 11 Residential groups and 1993 households in Hop Tien village. Agriculture production brings main source of income for people there.

According to statistics of Hai Duong statistical office in 2004, the gross product of Hop Tien is 37.5 billion VND, of which 22.57 billion comes from agriculture (about 60.2%), 10.1 billion from industry and construction and 4.6 billion from trade and services. The farmers here get almost income from winter crop (takes 70% of farming land) and upland crops such as onion, water melon…

About Education: there are 2 schools in Hop Tien commune 1 primary and 1 secondary school. The graduation rate is around 98% as statistics in last few years.

At present, 90% of households' access drilled wells and rain water, the remains using dug well.

(*Source: Statistical department of Hop Tien commune)*

Agriculture production in Hop Tien

With purpose not only economic goals but also community development, the Hop Tien agricultural production cooperative (APC) was established in 1996. This is an independent organization and works in accordance with the law of cooperative and accepts the management of local authorities. APC members work together for a more effective production and better livelihood of local people.

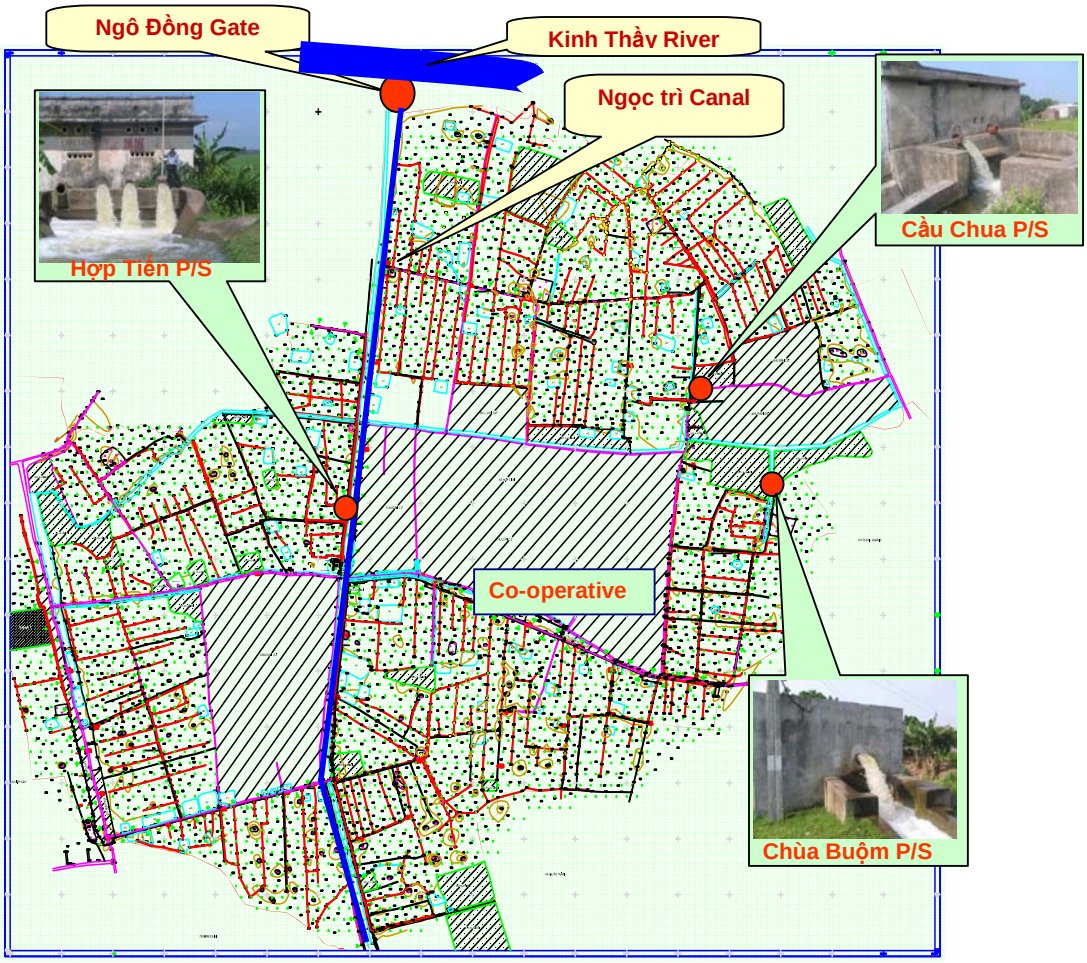


Figure 3.11 The outline of Hop Tien irrigation system (Note: P/S: Pumping station)

The irrigation system in Hop Tien belongs to Nam Sach irrigation system and it covers 363 ha irrigated area in this commune.

It takes water from Kinh Thay River through Ngoc Tri canal and Ngo Dong gate. The field topography is quite flat so this is propitious for rice cultivation and some upland crops such as: onion, garlic,

There are three pumping stations: Hop Tien, Cau Chua and Chua Buom that pump water to irrigate for all area of this commune.

3.4 Data collection

3.4.1 Data sources

Both primary and secondary data have been collected from two selected irrigation systems

Primary data collection

The primary data has been collected through field survey. It obtains the information about farmers (income, labor, and age), cropping systems, water adequacy, and crop yield. The information about technical and current situation gets by field survey and through household interview with standardized questionnaires. About physical, law, finance status, irrigation fee, institutional arrangement, we collect from Water use associations, local authorities, irrigation and drainage offices, etc…

Secondary data

Method for getting the secondary information is from offices, people's committees, cooperative management boards and cooperative leaders, internet, documents. It consists of information physical setting, institutional framework, socio-economic conditions, policy guidelines, etc.

3.4.2 Sample Size and Sampling procedure

Sample Size

To select households for interview purpose we use the stratified random sampling techniques. The number of households needed basing on the total number of population, the purpose of study, the accessibility of area. According to Taro (1967) the sample size determined by this formula

$$n = \frac{z^2 \pi(1-\pi)N}{z^2 \pi(1-\pi) + Ne^2}$$

Where

n: the sample size

z: factor

π: Confidence interval

N: total population

e: precision level

With $\pi = 0.5; z = 1.96$ for 95% confidence level the formula rewrited as follows

$$n = \frac{N}{1 + Ne^2}$$

The household questionnaires encompass both open ended and closed questions. For field surveys we use all three techniques: household surveys, information interview and field observation.

3.4.3 Data collection tools and techniques

- These techniques to be chosen are:

+ Participatory Rural Appraisal, field survey

+ Typical case research

+ Logical frame analysis;

+ Reviewing the literature, material, research

+ Group discussion

The household samples allows for sufficient representatives, feasibility and the development of typology. With this purpose we will choose households in systematic random method.

The detailed questionnaires take into account: household demographic characteristics, livelihood activities, labor allocation feature, decision making, the income structure, farming activities and budgets, markets and finance aspects, social, organizational aspects, issues and constraints.

The short question with purpose to validate and complete the initial finding from detailed questionnaires

Data collection is mainly based on individual interviews at household level, then the participation of community, local government,

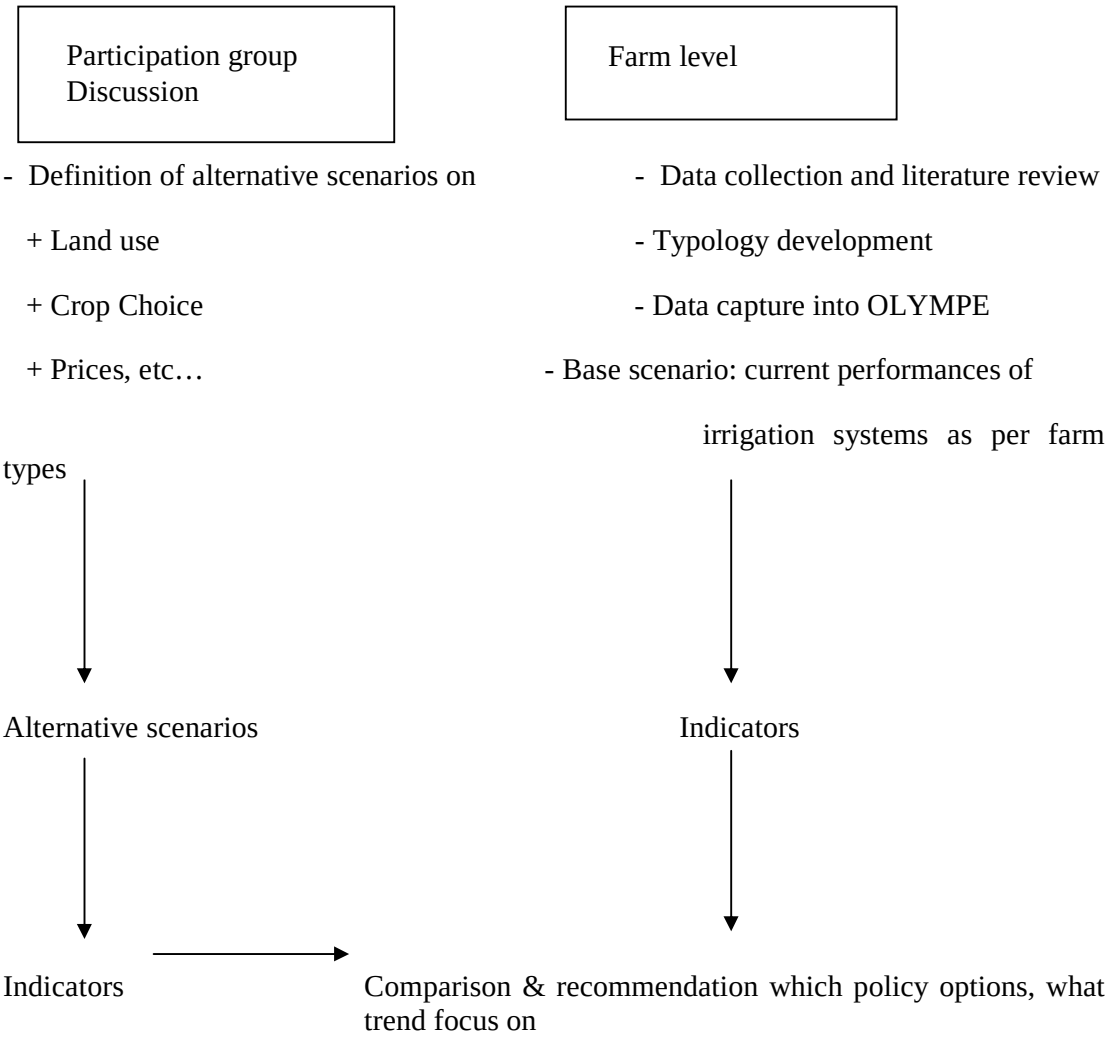


Figure 3.12 Framework for Methodology

3.5 Data analysis

3.5.1 Forming farming typologies

From the collected data together with descriptive statistics about households in terms of demographic and livelihood profile, then the typologies formed. Typologies to be classified basing on different characteristics and performances that they achieve. Typology of farming implies: cropping typology and typology of farmers.

+ Cropping Typology: showing farmers cropping strategy with scare water into the head, middle, the end.

+ **Farmers typology**: to be determined based on occupation and commercial orientation in farming.

Contingent analysis has been carried out to assess the farmers' willingness to pay for water services and then to investigate a possible water charging system

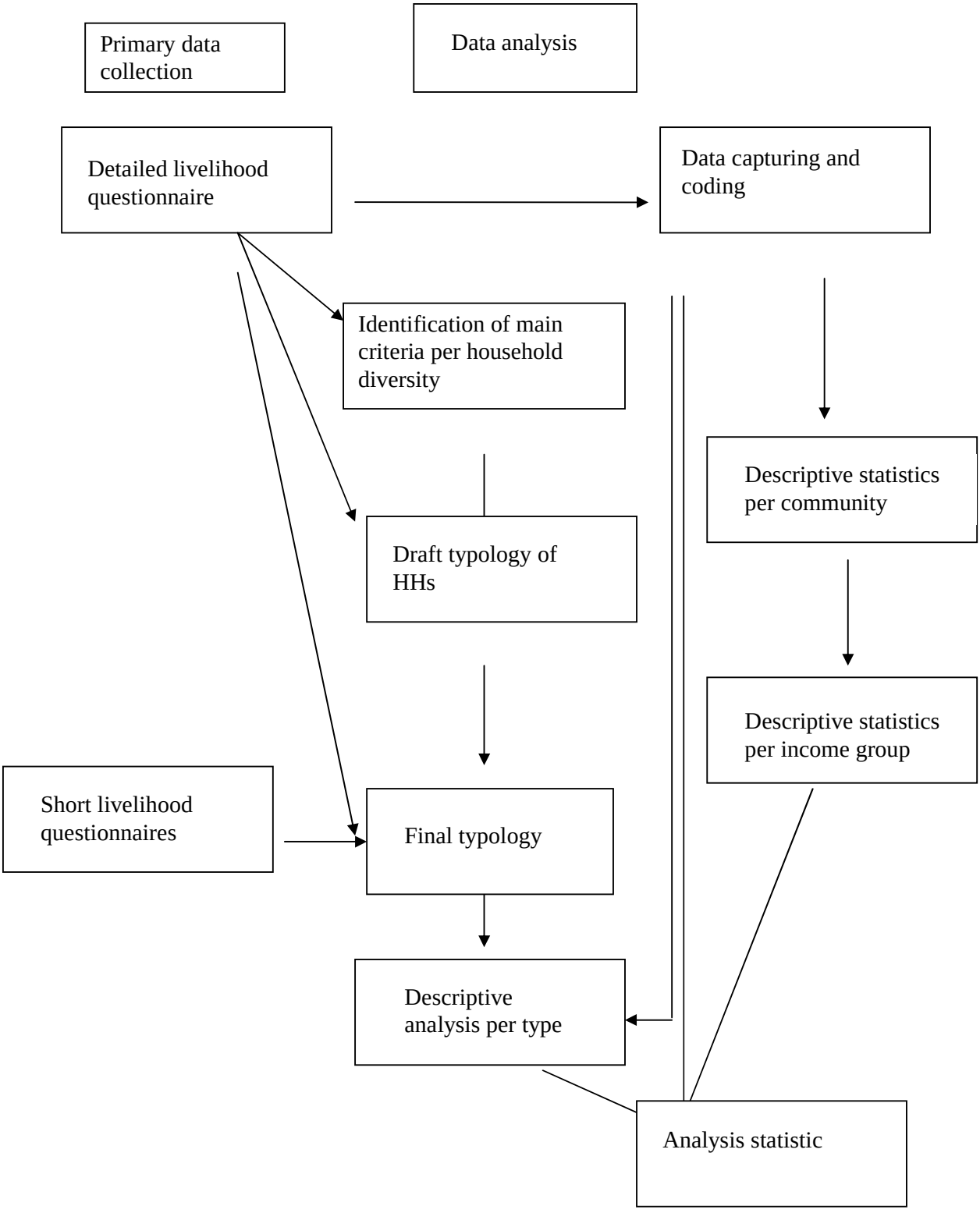


Figure3.13 Framework for data collection and analysis (Perret et al, 2005)

3.5.2 Using PCA technique to determine the dominant factors that make differences between HHs in irrigation systems

Key factors

Factor analysis are applied to group variables about socio-economic factors and production expenses variables, representative component as key factors that show the dominant components. Principal component determines linear functions of all observed variables. Only principal components which have high factor loading (eigenvalue ≥ 1) are examined. Principal components used factor-data reduction in the SPSS 13 software.

Two statistical measures are generated by SPSS to assess the factorability of the data: Bartlett's test of sphericity (Barlett, 19540, and the Kaiser-Meyer-olkin (KMO) measure of sampling adequacy. KMO index ranges from o to 1 with 0.5 suggested as the minimum for good factor analysis and the Bartlett's test of sphericity should be significant ($p<0.05$).

3.5.3 Capture data into OLYMPE software (Building scenarios)

Decision support tool

Olympe is a tool help for researchers looking for technical changes in farming systems. It can be used in various situations with different methodological approaches: comparison of cropping systems, economics of farming systems and resources management, prospective analysis, regional analysis, and even in association with simulation game.

Simulator for technical-economical analysis of farms

Olympe can simulate possible evolutions according to the choice of activities, allocation of production factors in the long period ten years or more. This software not only provides forecasts on economic results, cash flows, and manpower requirements but also assess the sustainability of production and farming systems. Furthermore it permits to test the robustness of systems towards the variability of climate or macro-economic conditions (prices, markets).

The software allows the evaluation of impacts of scenarios supposed by farmers with the help of the researchers. The Olympe database can be used as inputs of other optimization model and optimal solution in Olympe can be introduced as a scenarios. We also integrate Olympe with other models such as: geographic information system, agronomic model, multi-agent modeling.

A user-friendly interface helps the discussion between farmers and researchers and allows validating information stored in the database. Several backward and forward exchanges between farmers and researchers are necessary to validate the representation of the farming systems and calibrate the model so that it gives an acceptable representation of the present situation.

Olympe consists of a database on farming systems and a simulation tool. The data collected from surveys or secondary data to be stored in several module of database.

- The first module that define the categories of inputs (fertilizers, seeds, manpower…) and of outputs (crops and livestock products) including externalities (water pollution, erosion…),

- The second module defines the farming activities regarding cropping systems and livestock raising systems, characterized by the quantity of inputs used and their outputs. The annual crops and perennial crops, livestock breeding systems with different types of animals, as well as other activities such as: small-scale craft activities, post-harvest processing activities also to be defined. Using software we can calculate gross margin per hectare for crops of per animal for livestock and then to compare the different activity systems in terms of economic returns.

- Production or farming systems to be defined in the third module. They are characterized by their size (area, number of workers…) and the combination of activity systems (area of each crop, number of animals…). The software also mentions about capital, family expenses and other cash flows; some automatic calculations can be done (net income, gross income, total of receipts and expenses).

- The last module defines agrarian systems at regional level with a group of production systems using a defined area (irrigated scheme, locality, region…). It is possible in this level to compare the aggregated resource needs to the global level of available resources (for example water or labor), or the aggregated outputs to the available markets.

Different modules are illustrated as figure 4.2

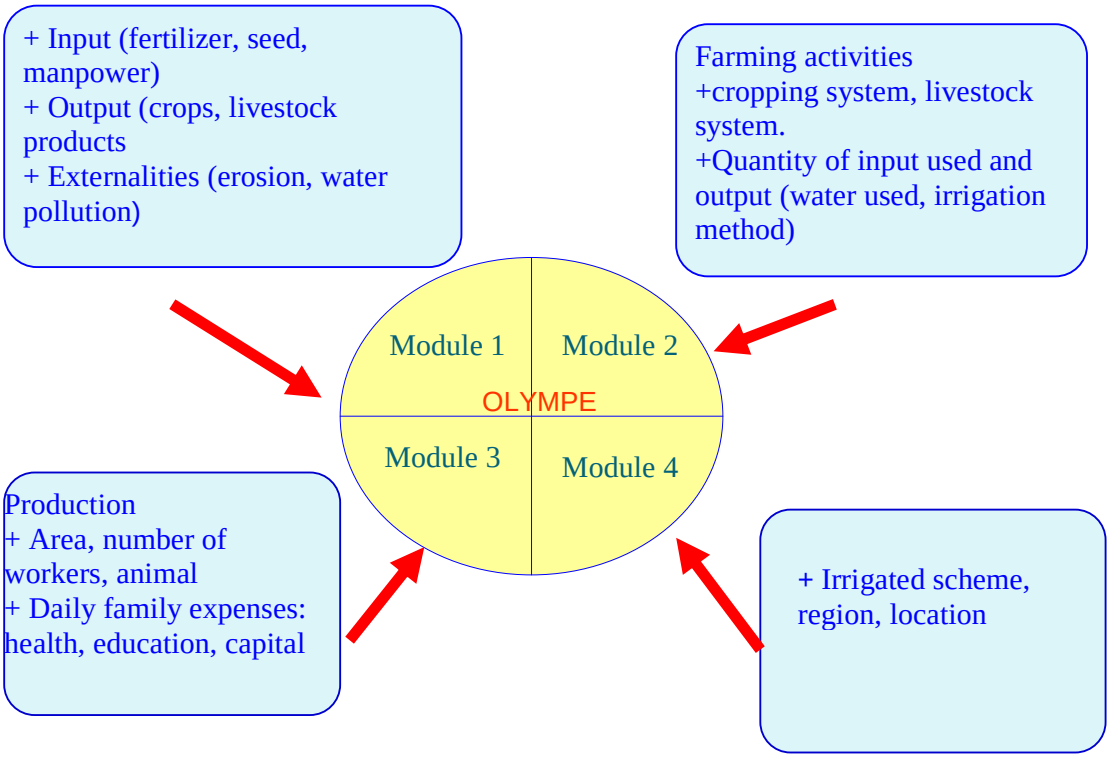


Figure 3.14 Different modules of OLYMPE software

With the simulation function some economic calculations are automated within the software. The various indicators can be calculated from the information stored in the database depending on the purpose of study (for example the calculation of total revenue of water fees at the irrigation scheme level)

To test various scenarios of evolution. Scenarios are determined through discussions with farmers and other stakeholders. They can concern:

- Changes in output and input prices such as new water prices, new price of fertilizer),
- Changes in farming practices with resulting changes in yields and production costs (due to the rehabilitation of irrigation schemes),
- Changes in combination of activities (e.g., increase in irrigation cropping and decrease in dry land cropping, introduction of new productions),
- Changes in the distribution of farm types, and any combination of the former.

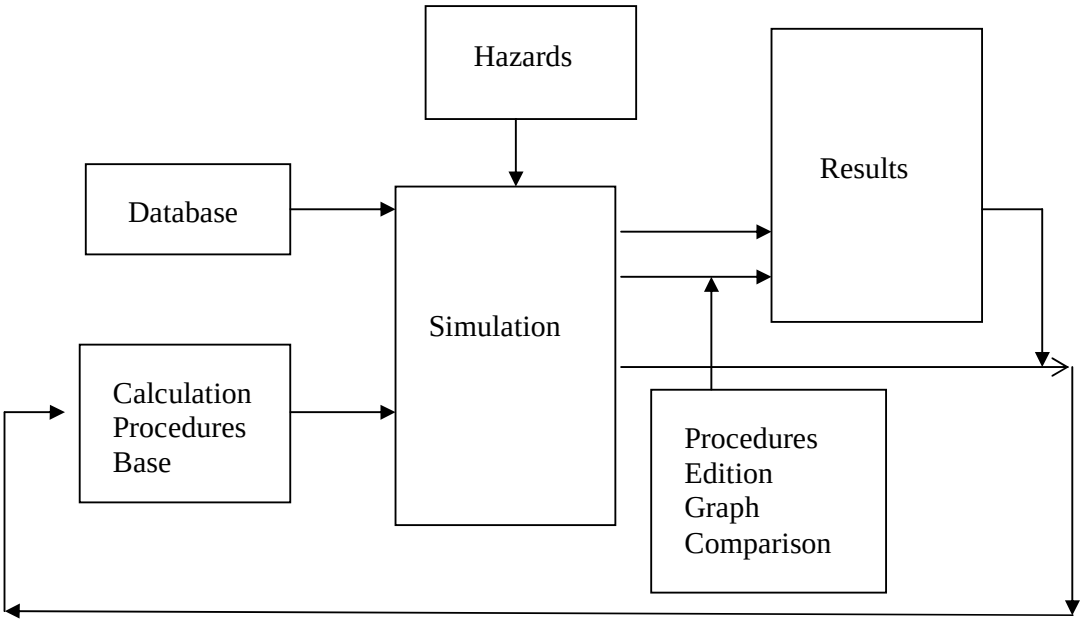


Figure3.15 Structure of Olympe software

Some output to be calculated automatically by Olympe

Net Margin = Net agricultural income = Results = Gross Margin – Financial cost – Fixed cost

Revenues = Non agricultural Income = off farm income

Total income = Net income + off farm income

Balance = Potential Cash Flow = Potential investment capability = Net income – Family expenses

Limitation of software

Olympe is not an optimization model and also can not calculate the optimal combination of activities for a farm or a scheme. So to get the optimal results we have to combine this software with other model.

It takes time to test for large number farming households

The software can not show the accuracy level of results attained.

Building scenarios by group discussion and comparing indicators for agricultural sustainability

The scenarios (irrigation management, water management, socio-economic, technical aspects) to be build basing on group discussion by farmers' participation. Through meetings we give out some changes and receive the feedback and overview from farmers, who take part directly in farming systems. Comparing some indicator by approach 1 and approach 2

CHAPTER 4

DATA ANALYSIS RESULTS AND DISCUSSION

4.1 General

4.1.1 Sample Size

The sampled households are selected basing on the population of two communes Hop Tien and Gia Xuyen. Assuming 10% precision level, where confidence level is 95% and P = 0.5. We calculation the number of surveyed households in two communes as following

With N = 2,085; e = 0.1 → n = 96 household

N = 1993, e = 0.1 → n = 95 household

Table 4.1 Number of survey households

Items	Gia Xuyen commune	Hop Tien commune
Total irrigated pumping area (ha)	194	363
Total households	2085	1993
Surveyed households	96	95

(Source: the data from statistical departments of Hop Tien and Gia Xuyen communes)

4.1.2 General information of two communes

Land use

Table 4.2 Land use condition of two communes Hop Tien and Gia Xuyen

No	Using purpose	Usable area (ha)	
		Gia Xuyen	**Hop Tien**
	Total natural land	**492.09**	**643.04**
1	***Agricultural land***	***318.63***	***376.26***
1.1	Farmland	290.55	368.35
	+ Paddy rice land	*256.24*	*333.19*
	+ Perennial plant land	*5.28*	*22.1*
1.2	Forestry land		
1.3	Aquacultural land	28.08	35.16
2	***Non-agricultural land***	***173.46***	

Population Table 4.3 Population status of Gia Xuyen and Hop Tien commune

No	Population status	Model site	
		Gia Xuyen	**Hop Tien**
1	Total number of households	2085	1993
2	Number of people	7922	7416
3	Number of female	4076	3924
4	Number of male	3846	3492
5	Number of people in the labor age	2161	2595
6	Percentage of people in the labor age/ total population	27.3 (%)	35 (%)

(Sources: From statistical department of Gia Xuyen and Hop Tien commune)

From the table it shows that populations in labor age in two communes are quite low (compare with 64.8% of Hai Duong province). This cause of the movement of people go to other provinces to go reclaiming virgin soil in mountain areas or go to work in capital. The labor force in agriculture becomes older.

96 sample HHs in Gia Xuyen and 95 HHs in Hop Tien commune selected for interview. From the questionnaire, synthetic all data we get some information like this

- The income in Gia Xuyen is based mainly on agriculture production, meanwhile in Hop Tien from poultry, husbandry.

- Income from non-farm management in Hop Tien basing mainly on salary from worker in industry companies meanwhile in Gia Xuyen basing on aqua-culture.

Expenses

- Gia Xuyen: A lot of money used for employing worker, harvest, transplant, for farming material like nylon, pesticide, maintenance …

- Hop Tien: Feeding for husbandry, poultry.

Organization Management of irrigation system

In Hop Tien irrigation system, the highest management level is Nam Sach irrigation enterprise, meanwhile, Gia Xuyen lies in Bac Hung Hai system, this is interprovincial irrigation system so the highest management level is Bac Hung Hai company below that is irrigation enterprises of each province

4.2 Analysis of livelihood systems in case study irrigation systems

4.2.1 Livelihood typology in Hop Tien commune

Livelihood typology refers to the main occupation and source of income of land occupiers. There are 95 households selected for interviewed survey. Some households occupy land in the irrigation system but not all are actually farming full time, some have diverse sources of income.

Table 4.4 Occupation of households in Hop Tien commune

Typology	**Main occupation**	**Survey HHs**
Type I	Full time farmer	55 (58)
Type II	Part time farmer	28 (30)
Type III	Self-employed	5 (5)
Type IV	Regular/Salaried Employee	7 (7)
Total		***95 (100)***

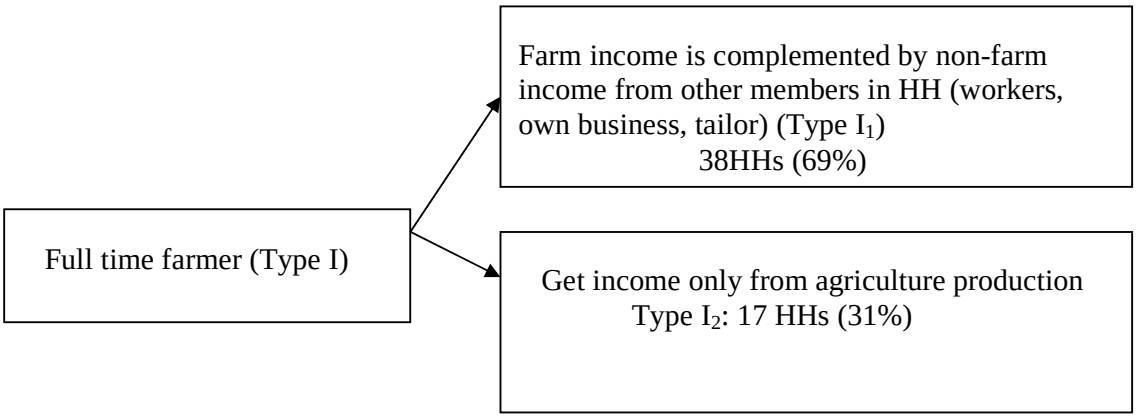
(Source: Author's survey, 2008); parenthesis is percentage of each type compare with total surveyed HHs

It can be seen that about 58% of households participate full time in agricultural production, and 30% population are part time farmers, besides agricultural production they do other works to increase income such as: clothes trades, mechanic, making brick, woodworker, cement, slaughter.

Non-farmers share 7% of total population. They work in private companies or foreign enterprises. Because of advantage location of this commune near highway, where concentrates many industrial companies.

Besides that, there are 5 % of population they get own mechanical company or clothes trades they get self-employed.

Here, we are going to focus on the type I and type II that have biggest and second biggest share in commune. For type I we classify this type into two subtypes



Full time farmer gets more off-farm income from other members in Households (**Type I1**). These farmers are head of household, together with their wife or husband they fully involved in farming, they get commercial oriented. The other members (their offspring) own small business, work in company, or they are tailors who earn more income for family. This type counts 69% of sampled HHs

ii) Full time farmer get income only from agriculture production (**Type I2**). This type has second majority of surveyed HHs (31%). This type all member in HH participate in agriculture. Their income based on selling agricultural products.

The main difference between type I1 and type II are: part-time farmer group (type II) who has cultivated land, they hire labor to transplant; harvest and the product only supply for their family's demand, no commercial oriented. They get part time job from making brick, mechanical companies. The main income gets from part-time jobs. This category counts for 8.58% of sampled HH.

- Subtype of farmers

The farmer type I1 (full time farmers get income is complemented by other member also is divied by sub type by difference in production style

4.2.2 Livelihood typology in Gia Xuyen commune

Gia Xuyen is one commune with more than 90 percent agricultural labor. The main criterion for determining typologies of households this commune is cropping patterns. These types to be used to assess the income performance of households

Table 4.5 Occupation of households in Gia Xuyen commune

Typology	Description	Amount	Percentage
Type I	The full-time farmer with different cropping systems.	78	81.3 %
Type II	The full-time farmer with animal production systems: fish pond, animal husbandry, grass for animal.	4	4.2 %
Type III	The Part –time farmer with horticultural activities (decorate plant with peach flower around)	5	5.2 %
Type IV	Salaried employee	3	3.1 %
Type V	Self – Employee	6	6.2 %
Total		96	100%

Type I: These farmers occupied of a large mount 78 HHs (81.3%). Most of them cultivate agricultural production follows by rotation of crops: Spring Rice, water melon, pear shape, cabbage. They sell production to commercial people at home. The working age of this typology is quite high. They spend full time in field. They live in the tail, head or even in the middle of system.

Type II: Most of them come from the farmers get land with low elevation. Rice cultivation do not bring high yield so they change to agricultural system: Fish pond, animal husbandry, and grass. Because of large investment in initial period, so they get the bank loan and pay money in following years after. This typology accounts for 4.2 percent in interview households.

Type III: They are people, who get commerce mind with the knowledge about decorate plant. Nearly all of them are retired officers (counts for 5.2%).

Type IV: They are young people, who occupy land in the system, but are not farmers, they work for private companies, industrial parks and get employed salary (count for 3.1%)

Type V: They open small grocery shops, carpenter's shop to earn more income. They only rice cultivation with small size to serve for their family's demand. (Count for 6.2

4.2.3 Conclusion

In Hop Tien we have full-time farmer type and part-time farmer type; but in Gia Xuyen the most are full-time farmer. The number of non-farmer in Hop Tien is much higher than in Gia Xuyen (30.11% Regular salaried employee; 3.26% self-employed compares with 3.1% and 6.2% of them in Gia Xuyen. This caused by the advantage location of Hop Tien near highway, industrial zone so the people work in the industrial sector highly. In contrast with Gia Xuyen, most of farmer in the system are full-time farmers.

4.3 Factors explaining the differences between households in the irrigation systems

4.3.1 Choosing the factors

The socio factor includes (age of head household, education level of head household, gender of head household, number of people in each family, number of farm labor in each family, expertise in farming of head households, intention for crop diversification)

The economic factors compose: the size of land holding, income, cropping system style, rice yield.

The physical factors: location of household in the irrigation system, elevation of farm land of household.

The detail for different factors were selected for PCA testing (Appendix B table B1)

Run PCA we find the key factor that explain the differences between households in two irrigation systems.

4.3.2 Factors explain the differences between households in Hop Tien commune

a) Key factors that explain for livelihood diversification in Hop Tien

The dominant factors that can represent best for the socio-economic, technical, physical condition in the Hop Tien commune

Table 4.6 KMO and Bartlett's Test for factors explaining livelihood diversification in Hop Tien

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.519
Bartlett's Test of Sphericity	Approx. Chi-Square	152.355
	df	91
	Sig.	.000

KMO = 0.519 > 0.5 and p = 0.000 < 0.05 and the value eigenvalue >=1 were represented for other factors, see the result on table

Table 4.7 Rotated Component Matrix(a) for factors explaining livelihood diversification in Hop Tien

	Component					
	1	2	3	4	5	6
Expertise of head farmer	**.865**	.129				
Age of head person in family	.865			-.109	.105	
Number of farm labor in each family	-.194	**.790**		-.237	.178	-.103
Number of people in each family	.178	.764		.156		.155
Income resources of household	-.294	-.479		-.305	.173	.222
Size of land holding	.230	.206	**.723**	.159	.165	
Gender of head person in household	.103	-.160	-.669	.382		.219
Elevation of hh's farm		-.295	.600	.220	-.101	
Different kind of livestock feeding	-.124		.169	**.747**	.233	.106
Cropping system styles		.101		.571	-.225	-.260
Yield of rice			-.113		**.779**	-.280
Location in irrigation system		.145	.109		.665	.286
Intention for diversification	.108		-.150			**.835**
Education level of head person	-.405	-.189	.360	-.125	.138	.459

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a Rotation converged in 11 iterations.

In total 14 factors that were selected for checking we find out 6 factors that represent the best for diversification of livelihood in Hop Tien are

+ Expertise of head farmer

+ Number of farm labor in each family

+ Size of land holding

+ Different kind of livestock feeding

+ Yield of rice

+ Intention for diversification

These factors are selected with high factor loading (eigenvalue ≥ 1)

b) Statistical test to find the significant difference between farmers' types with the key factors

Using independent samples t-test for the parametric factors "Number **of farm labor in household", "Size of land holding in each family", "rice yield".**

Table 4.8 Group Statistics for factors explaining livelihood diversification in Hop Tien

Variables	Farmer' type	N	Mean	Std. Deviation
Number of farm labor in each family	Type I	55	2.27	.870
	Type II	28	2.29	.937
Size of land holding	Type I	55	.19941	.034411
	Type II	28	.19536	.034185
Yield of rice	Type I	55	5.5109	.39048
	Type II	28	5.5857	.40251

Table 4.9 Independent Samples Test for factors explaining livelihood diversification in Hop Tien

Variables		Levene's Test for Equality of Variances		t-test for equality of Means		
		F	Sig.	t	df	Sig (2-tailed)
Number of farm labor in each family	Equal variances assumed	.216	.644	-.063	81	.950
	Equal variances not assumed			-.061	51.001	.951
Size of land holding	Equal variances assumed	.007	.934	.509	81	.612
	Equal variances not assumed			.510	54.756	.612
Yield of rice	Equal variances assumed	.272	.603	-.817	81	.416
	Equal variances not assumed			-.809	52.988	.422

The result in column (Sig (2-tailed)) shows that there is no significant difference between two farmers' types about "number of farm labor in each family"; "size of land holding" and "rice yield"

For **non-parametric test, Mann-Whitney** test is used for other factors "farming expertise of head person in household" "different kind of livestock feeding" and "intention for diversification". The result shows that

Table 4.10 Test Statistics (a) of non-parametric factors that explaining livelihood diversification in Hop Tien

	Expertise of head farmer	Different kind of livestock feeding	Intention for diversification
Mann-Whitney U	560.000	696.500	762.000
Wilcoxon W	966.000	1102.500	2302.000
Z	-2.208	-.741	-.082
Asymp. Sig. (2-tailed)	**.027**	**.459**	**.934**

a Grouping Variable: Farmer's Types

The results shows that there is a significant difference in expertise of farmer between farmer's type I and farmer type II ($p = 0.027 < 0.05$)

There is no significant difference between livestock feeding and intention for diversification between group I and group II. ($p > 0.05$)

To sum up from PCA and statistical test we find out six factors that present best for the diversification between households in Hop Tien, of which the factor "expertise of head person in household" has the significantly different statistic.

4.3.3 Factors explain the differences between households in Gia Xuyen commune

a) Key factors that explain for livelihood diversification in Gia Xuyen

Table 4.11 KMO and Bartlett's Test for factors explaining livelihood diversification in Gia Xuyen

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.557
Bartlett's Test of Sphericity	Approx. Chi-Square	198.690
	df	91
	Sig.	.000

Table 4.12 Rotated Component Matrix (a) for factors explaining livelihood diversification in Gia Xuyen

	Component					
	1	2	3	4	5	6
Age of head person in family	**.891**					-.191
Expertise of head farmer	.874					
Education level of head person	-.662		-.297	.124		-.301
Number of people in each family		**.834**		-.103		
Number of working labor in each family		.730				
Income resources of household	-.154	.433	.233	.338	-.411	
Elevation of hh's farm			**.843**			.106
Different kind of livestock feeding	-.221	-.145	-.601	-.410	-.182	
Cropping system style			.306	**.755**		-.102
Yield of rice		-.128		.589		
Size of land holding				.142	**.802**	
Gender of head person in household	.159	-.294		.346	-.450	.315
Intention about diversification	-.148		.158	-.126		**.797**
Location in irrigation system	.126	.328	-.409	.337	.295	.474

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a Rotation converged in 9 iterations.

Similarly in Hop Tien, there are 6 key factors that represent best for the difference between households in Gia Xuyen, they consist

+ Age of head person in family

+ Number of people in each family

+ Elevation of hh's farm

+ Cropping system style

+ Size of land holding

+ Intention about diversification

b) Statistical test to find the significant difference between farmers' types with the key factors

Using one-way ANOVA for parametric factors include: "Age of head person in household"; "Number of people in each family"; "size of land holding"

Table 4.13 Statistic description of key parametric factor that explaining livelihood diversification in Gia Xuyen

Variances	Farmers' types	N	Mean	Std. Deviation	Min	Max
Age of head person in family	Type I	78	48.83	4.229	37	65
	Type II	4	42.00	7.348	36	52
	Type III	5	46.20	2.775	42	49
Number of people in each family	Type I	78	3.96	.440	3	5
	Type II	4	4.00	.000	4	4
	Type III	5	4.00	.000	4	4
Size of land holding	Type I	78	.2443	.24420	0.07	1.8
	Type II	4	.2248	.03133	0.2	0.27
	Type III	.1896	.01345	.00601	0.18	0.21

Table 4.14 ANOVA test for factors explaining livelihood diversification in Gia Xuyen

Variances	F	p
Age of head person in family	5.421	.006
Number of people in each family	.034	.967
Size of land holding	.138	.872

One way between groups analysis of variance are conducted to explore the difference between farmers' types by factors.

There is a significant difference between there types in age of head farmer ($p = 0.006 < 0.05$). There is no difference between number of people in each family and size of land holding between farmers' types

Table 4.15 Multiple Comparisons **(**Tukey HSD**)** for factors explaining livelihood diversification in Gia Xuyen

Dependent Variable	(I) Farmer's Types	(J) Farmer's Types	Mean Difference (I-J)
Age of head person in family	Type I	Type II	**6.833(*)**
		Type III	2.633
	Type II	Type I	**-6.833(*)**
		Type III	-4.200
	Type III	Type I	-2.633
		Type II	4.200
Number of people in each family	Type I	Type II	-.038
		Type III	-.038
	Type II	Type I	.038
		Type III	.000
	Type III	Type I	.038
		Type II	.000
Size of land holding	Type I	Type II	.0195
		Type III	.0547
	Type II	Type I	-.0195
		Type III	.0352
	Type III	Type I	-.0547
		Type II	-.0352

Post-hoc comparisons using turkey HSD with the results in table 4.15 indicates that the mean score of type I (M = 48.83; SD = 4.229) is significantly different from group II in factor “Age of head person in family”. Group III (M = 46.20; SD = 2.775) do not differ significantly from either group I or II.

Kruskal Wallis test for other factors (non-parametric)

Table 4.16 Statistical description of non parametric factors explaining livelihood diversification in Gia Xuyen

Variables	**Farmers’ types**	**N**	**Mean rank**
Elevation of hh's farm	Type I	78	45.82
	Type II	4	2.50
	Type III	5	**48.80**
Cropping system style	Type I	78	43.47
	Type II	4	3.13
	Type III	5	**85.00**
Intention about diversification	Type I	78	**45.16**
	Type II	4	32.88
	Type III	5	34.80

Table 4.17 Test Statistics (a,b)

Variables	Elevation of hh's farm	Cropping system style	Intention about diversification
Chi-Square	26.404	31.199	3.356
df	2	2	2
Asymp. Sig.	**.000**	**.000**	**.187**

a Kruskal Wallis Test

b Grouping Variable: Farmer's Types

There is a significant difference about elevation of households' farm and cropping system styles between there farmers' types. There is no difference between farmers' types in intention about diversification.

4.3.4 Discussion

The key factors can be tabulated in this table

Table 4.18 Key factors that explain the diversification in the irrigation system

No	**Gia Xuyen**	**Hop Tien**
1	Age of head person in household	Farming expertise of head person in household
2	Number of people on each family (family size)	Number of farm labor in household
3	Elevation of household's farm land	Size of land holding of each family
4	Cropping system styles	Different kinds of livestock feeding
5	Size of land holding	Rice yield
6	Intention for diversification	Intention for diversification

The difference comes mainly from socio factors (expertise, age of head person, family size farm size, intention for crop diversification). Gia Xuyen also has the difference in "cropping system style", meanwhile in Hop Tien is "different kind of livestock". These key factors can help the planners or decision makers see an overall picture about the diversify between households in socio-economic, physical and institutional foundation.

Besides the similar socio- economic factors that explain the diversity of households in two communes, the result also shows the typical feature in diversification of two these communes as follows. The diversification in Gia Xuyen performs by the diversity of cropping system; whereas, in Hop Tien it comes from different kind of livestock.

In total 6 key factors and from statistical test, the result show that

+ In Hop Tien there is only one factor "Expertise of head person in household" that show the significant difference between farmers' types in this commune

+ In Gia Xuyen these following factors “Age of head person in family”, “Elevation of hh's farm” and “Cropping system style” has significant difference between households. This imply that different household they get different cropping system style, and their farms lie in the different elevation and the age of head people in household also differ.

4.4 Analysis of agricultural production systems in case study irrigation systems

4.4.1 Agricultural production system styles in Hop Tien commune

In both commune Gia Xuyen and Hop Tien paddy rice is the main crop. The farmers in Hop Tien cultivate 3 crops per year; meanwhile there are 4 or 5 crops per year.

Crop Calendar in Hop Tien

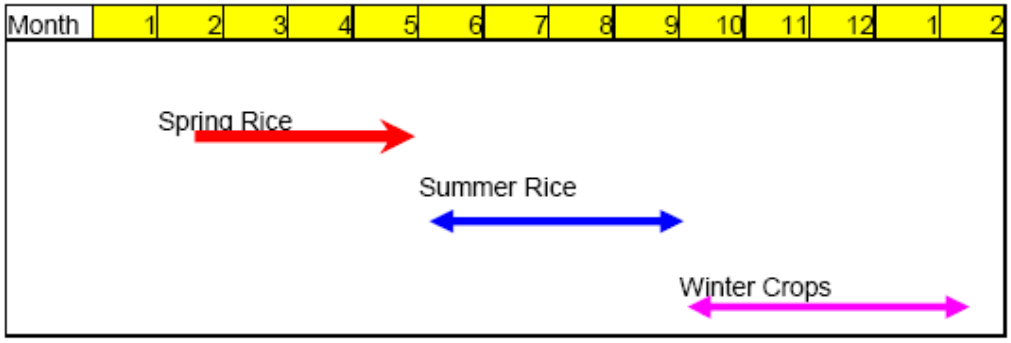


Table 4.19 Crops in Hop Tien commune

Crop	Cultivated area of whole commune(ha)	Average yield (ton/ha)	Calendar	Market price (VND)
Spring rice	328.51	5.6	15 January- 25 May	2,200/kg
Summer rice	328.51	5.3	10 June- September	2,200/kg
Potato	8.7	13.8	Oct- December	1500/kg
Onion	6.6	11.1	Oct- December	1500/kg
Water melon	18.5	23.06	Oct- December	700/kg
Pumpkin	16.2	26	Oct- December	700/kg
Tomato	2	10.2	Oct- December	4000/kg
Sweet potato	6	13.8	Oct- December	600/kg
Corn	5	3.2	Oct- December	2625/kg
Special onion	46	7.2	Oct- December	1500/kg

(Source: Statistical department of Hop Tien commune)

Three farmer types in Hop Tien with 6 agricultural production systems

Style1: only Rice (spring and summer rice)

Style 2: Rice, upland crops, animal husbandry

Style 3: Rice, upland crops, fruit-tree, animal husbandry

Style 4: Rice, upland crops

Style 5: Rice, upland crops, animal husbandry, fish pond

Style 6: Rice, animal husbandry, fish pond

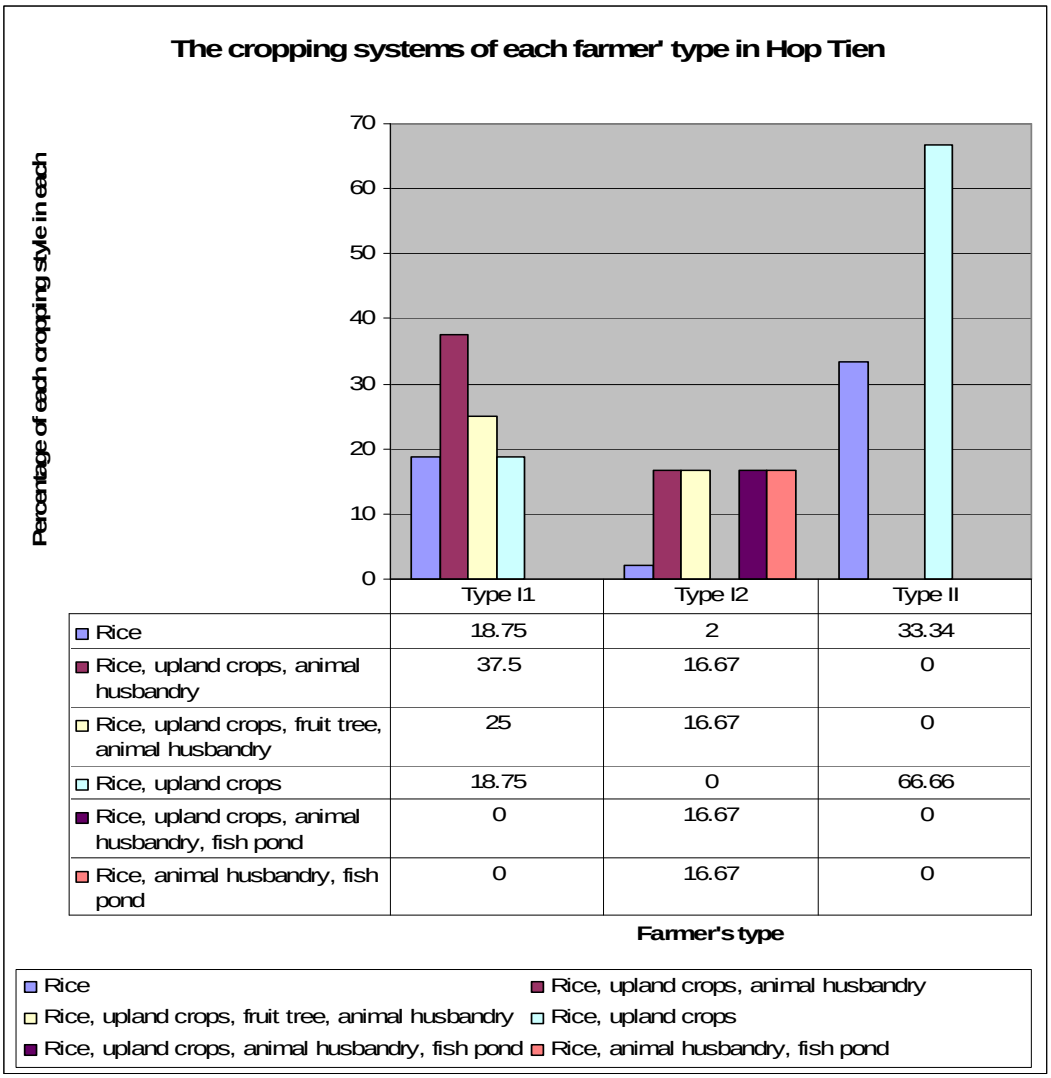


Fig 4.1 Cropping systems of farmers' types in Hop Tien

The figure shows that in farmer type I1: The farmer have 4 cropping system style, of which style: Rice, upland crops, fruit-tree, animal husbandry with highest percentage 25% of total HH in this type

Similarly, in farmer type I2: The farmers with 5 cropping styles and the style rice, animal with biggest share (33.33%)

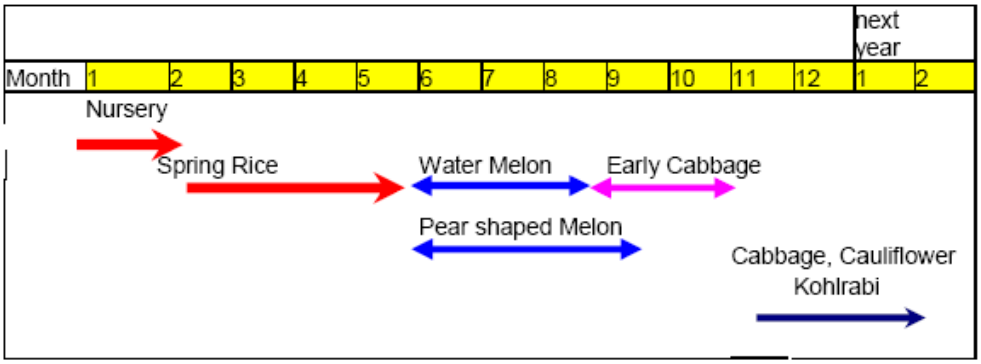
In type II, the farmer cultivate with 2 styles: Rice or Rice and upland crops.

4.4.2 Agricultural production system styles in Gia Xuyen commune

Crop Calendar in Gia Xuyen

In general, development of upland crops is main feature of Gia Xuyen commune. The main alternation of cropping patterns in this region is spring rice-water melon-early cabbage-cabbage and peach flower all the year around.

Crop calendar in Gia Xuyen



Crop diversification, suitable soil, climate and abundant water are advantages for planting development here.

Table 4.20 Cropping systems in Gia Xuyen commune

Numbering	**Cropping system**	**No of sample HH**	**Percentage (%)**
1	Spring rice- Summer rice	24	31
2	Spring rice -Water melon-Summer rice-Potatoes	3	4
3	Spring rice-Water melon-Winter vegetables	31	40
4	Spring rice-Soybean-Special onion	9	11
5	Spring rice-Summer rice- Winter vegetable	12	15
Total		***78***	***100***

There are five dominant cropping patterns in farmer type I. As shown in table, the biggest percentage of responses (40% of the type) with the cropping system: Spring rice-Water melon-Winter vegetables; subsequent to style: spring rice-summer rice (31% of sample HH type I); style: Spring rice-Summer rice- Winter vegetable (15%) and Spring rice-Soybean-

Special onion (11%), the lowest style come from : Spring rice -Water melon-Summer rice-Potatoes (4%)

4.5 Factors explaining the diversification in agricultural production styles in two communes

4.5.1 Choosing the factors

There are 12 factors selected for analysis to find out the key factors that explain the differences in production between farmers.

The factors are selected including: total amount of input per one unit of land for production (seed, potassium, Nitrogenous, phosphate, herbicide) (one unit of land = 1 sao = 360 m2), machine expenses for 1 crop, cropping system style, area cultivated, intention for crop diversification, location of farm land in the irrigation system, farmer's satisfaction with current situation of water distribution, market condition for product consumption. For detail see Appendix B table B2

4.5.2 Key factors explaining the diversification in agricultural production styles in Hop Tien commune

In total 12 factors considered we find out 5 key factors that explain the differences between households in the irrigation system are: (see Appendix B table B3)

- Cropping system styles
- Farmer's intention about crop diversification
- Farmer's satisfaction with current situation of water distribution
- Potassium used for 1 unit of land (1 sao = 360 m2)
- Location of farm land in irrigation system

One way ANOVA is used for parametric test and Kruskal Wallis Test is used for non-parametric test to show the significant difference between factors.

Table 4.21 ANOVA test for factor that explaining cropping diversification in Hop Tien

Potassium used for 1 sao rice

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	13.060	10	1.306	4.134	.000
Within Groups	22.747	72	.316		
Total	35.807	82			

Sig ($p = 0.000 < 0.05$), there is a significantly different statistic in the factor "Potassium used for 1 sao rice ". It mean that different farmer's type they use amount of potassium in the different quantity.
For non-parametric factors we use Kruskal Wallis test and the result show that
Test Statistics (a,b)

	Name of different crops	Farmer's intention for crop diversification	Farmer's satisfaction with current situation of water distribution	Location of Household in irrigation system
Chi-Square	9.831	9.818	32.452	6.433
df	10	10	10	10
Asymp. Sig.	.455	.457	**.000**	.778

a Kruskal Wallis Test
b Grouping Variable: Famer's type

The significant different statistic lies in the factor "Farmer's satisfaction with current situation of water distribution". Different farmer's type they have different satisfaction level with situation of water distribution. For other factors, there is no significant difference.

4.5.3 Key factors explaining the diversification in agricultural production styles in Gia Xuyen commune

Similarly in Hop tien, there are five dominant factors investigated to show the diversification in agricultural production in Gia Xuyen, they consist: Cropping system style, Location of household's farm in irrigation system, Total amount of seedling per land density (kg/sao; 1 sao=360m2), Herbicide used for 1 crop, Potassium used for 1 unit of land

Table 4.22 ANOVA test for factor that explaining cropping diversification in Gia Xuyen

Variables		df	F	Sig
Total amount of seedling per land density in spring season (kg/sao; 1 sao=360m2)	Between Groups	4	2.246	.072
	Within Groups	73		
	Total	77		
Herbicide used for 1 crop	Between Groups	4	.905	.465
	Within Groups	73		
	Total	77		
Potassium used for 1 sao rice	Between Groups	4	2.096	.090
	Within Groups	73		
	Total	77		

One way ANOVA test shows there are no differences in three factors between households in Gia Xuyen.

Non parametric test was applied for two factors and the result in this table

Test Statistics(a,b)

	Location of Household in irrigation system	Cropping system
Chi-Square	8.523	77.000
df	4	4
Asymp. Sig.	.074	**.000**

a Kruskal Wallis Test

b Grouping Variable: Farmer's type

The result in this table show the cropping system styles are different between farmer's types.

4.5.4 Discussion

In Hop Tien there are two factors "Potassium used for one crop" and "Farmer's satisfaction with current situation of water distribution" present the difference significantly between agricultural production systems of farmers' types.

The factor "Satisfaction with water distribution" has positive effects to the irrigation managers in water supply management. The farmer in the head of system they have convenience in take water into your field, and the tail farmer they usually lack of water that causes the reason in difference in satisfaction with the water supply

In Gia Xuyen the significant difference comes from factor "cropping system style". Cropping system styles depict alternative styles in cropping system, the diversity of alternative crops in their production system.

Table 4.23 Comparison between key factors explain the different cropping systems in Gia Xuyen and Hop Tien commune

Key factors explain the different agricultural production styles	
Gia Xuyen	Hop Tien
- Cropping system styles - Location of farm land in the irrigation system - Amount of seedling used for one unit of land (1 sao = 360 m2) - Herbicide used for 1 crop - Potassium used for one unit of land	- Cropping system styles - Farmer's intention about crop diversification - Farmer's satisfaction with current situation of water distribution - Potassium used for 1 unit of land (1 sao = 360 m2) - Location of farm land in irrigation system

In Gia Xuyen the key factors that come from cropping system styles and three from economic factors (amount of input used: seedling, herbicide, and potassium) and one physical factors (location of the farm)

Meanwhile, in Hop Tien, two factors come from institutional aspect (intention for crop diversification and satisfaction with current situation of water distribution), location of farm, potassium use for one unit of land and cropping system style.

We see that the most important factor influences to agricultural production system styles in two these communes are cropping system style.

The second key factor in Gia Xuyen is **Location of farm household in the irrigation system.** In Hop Tien, the second factor is the "intention of farmer about the diversification in production" . The main factors of Hop Tien commune mainly come from the conscious about diversity and their attitude with actual situation in water supply, meanwhile three in total five factors from Gia Xuyen they are the fertilizer used or seedling used.

+ In Gia Xuyen should improve, training the farmer in production technique about using fertilizer in a reasonable way.

+ Hop Tien, should concentrate more on the institution and management aspects about water supply and the diversification in production.

4.6 Cropping Intensity

Cropping Intensity = (Total cropped area / total cultivated area)*100

Hop Tien commune

Table 4.24 Cropping intensity in Hop Tien commune

Year	Area (ha)							
	Spring Rice	Summer Rice	Corn	Vegetables	Winter crops	Total cropped area	Total cultivated area	Cropping intensity
2005	320	320	14.1	79.6	177	910.7	392.87	***231.81***
2006	319	319	0	23	177.5	838.5	341.1	***245.82***
2007	324.1	328	0	18.58	167	837.68	341.1	***245.58***
2008	306.31	333.19	0	16	172	827.5	341.1	***242.60***

Gia Xuyen commune

Table 4.25 Cropping intensity in whole Gia Xuyen commune

Year	Area (ha)								
	Spring Rice	Spring Vegetable	Decorated Plants	Summer-Autumn Crops	Summer Rice	Winter Crops	Total Cropped Area	Total cultivated Area	Cropping intensity
2005	240.6	58	15.1	167	118	462	1060.7	290.55	***365.07***
2006	200	40	13.5	126.5	120	464.6	964.6	290.55	***331.99***
2007	200	48	12.5	118	120	560.4	1058.9	290.55	***364.45***
2008	220	21	26.1	118	100	560.4	1045.5	290.55	***359.83***

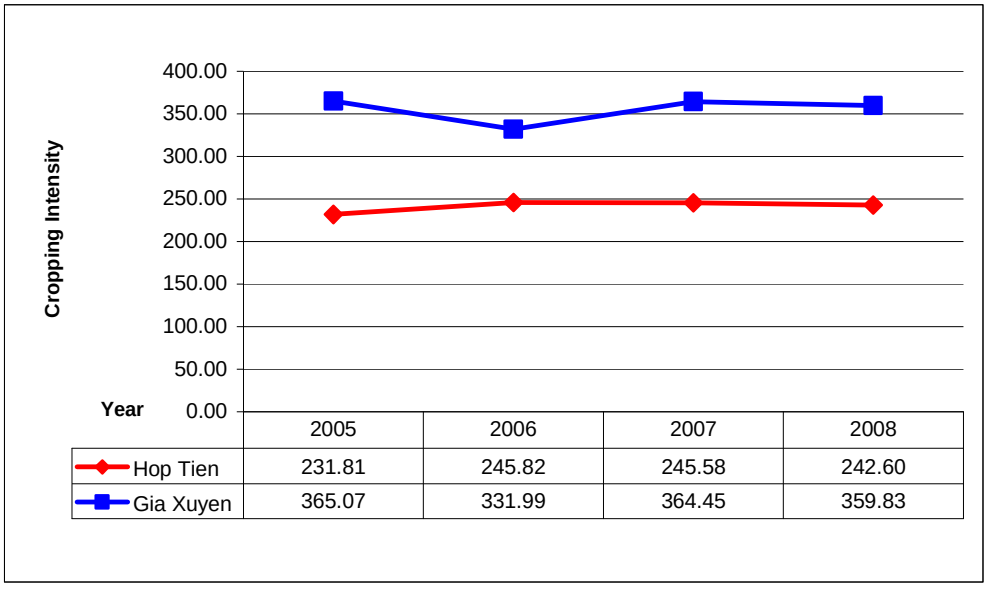


Fig 4.2 Comparison cropping intensity between two communes Hop Tien and Gia Xuyen

The average cropping intensity in Gia Xuyen is 359.83 percent (in 2008); it is 1.5 time higher than this in Hop Tien with 242.60 percent. This portages the high intension in crop cultivation in Gia Xuyen with more than four crops per year.

4.7 Water productivity of system

Water Productivity (WP) is ratio of economic yield per total amount of water used for crop. It is one of criteria to assess performance of rained or irrigated agriculture

$$WP = \frac{Weight\_of\_grain(kg/ha)}{Total\_amount\_of\_water\_used\_per\_unit\_area(mm)}$$

Total amount of water required for rice includes: Water requirement for land preparation, water losses in evaporation, deep percolation and seepage and metabolic activities.

For calculating water requirement we have record book about: pumping operation period, number of operated pumps, discharge of each pump, we calculate the total amount of water supply from the head of system, and know the irrigate area we define irrigation dose (m3/ha) as follows

We have two pumps operation, know the total hours pumping, discharge of each pump we find total amount of water supply

Total amount of water = total pumping hours * Discharge of pump

Total irrigated area is 177 ha. Discharge of each pump Q = 0.235 (m3/s).

Table 4.26 Water productivity of Quan Phan system- Gia Xuyen commune

No	Year	Yield (t/ha)	Total Water Used (m3/ha)	Water Productivity (ton/m3)	Water Productivity (kg/ha.mm)
1	2000	5.911	16500.35	0.000358	3.58
2	2001	2.85	16433.43	0.000173	1.73
3	2002	6.081	18533.61	0.000328	3.28
4	2003	6.273	14380.57	0.000436	4.36
5	2004	6.374	18118.1	0.000352	3.52
6	2005	6.382	15714.73	0.000406	4.06
7	2006	6.443	17911.3	0.000360	3.60
8	2007	5.84	16696.22	0.000350	3.50
9	2008	6.94	8239.371	0.000843	8.43
Average				***0.000401***	***4.01***

(Data source: Irrigation Enterprise in Gia Xuyen and Author's calculation)

Conclusion:

For this calculation we only mention economic water productivity because here, we do not consider the rainfall happened in region, moreover, the water from pumping station move to the field through canal, the amount of water loss is very large by evaporation, leak out in canal and drainage in field when frequently rain occurs. For actually water consumption by crop we can make some measurement in the gate of field by small dam and observe the water level, water supply time period, discharge of water… We can calculate the actual water consumed by crop.

4.8 Capture input data of two irrigation systems into OLYMPE software

4.8.1 Choosing typical farmers of each farmers' types

As the research in previous section (in section 4.2), the farmers are classified into five types in Gia Xuyen and four types in Hop Tien.

For each farmer type we choose the typical farmer based on

+ This farmer can represent for the other farmers in this type about the size of land occupy, production method

+ Typical farmers depict a general outlook about its typology

4.8.2 The results of Hop Tien commune

The main of this research focus on the farmer operation model to find out the best model that get the highest benefit for farmer, so here the farmers' types in Hop Tien are tested included type I1 (full time farmer is complemented by non-farm income from other member in family), type I2 (full time farmer only get income from agricultural products), type II (part time farmer).

Type I1, type I2 and type II are also divided into small types I1_1; I1_2; I1_3; I1_4; I2_1; I2_2; I2_3; I2_4; I2_5; II_1 and II_2 based on the difference between cropping systems

a) Profit of farmers' types

Table 4.27 Economic results of farmers' types in Hop Tien

Current unit: VND

No	Farmers' types	Production styles	Total product income	Total operation cost	Margin (or profit)(VND)
1	Type I1_1	Rice; upland crop (onion); animal husbandry (pig)	**43,394,000**	**27,336,320**	**16,057,680**
2	Type I1_2	Rice, upland crops (Squash, Onion), fruit-tree (Longan); animal husbandry (chicken, goose)	**18,325,400**	**16,085,950**	**2 239 451**
3	Type I1_3	Rice, corn, upland crops (Squash, Water melon); animal husbandry (chicken, goose; pig)	**51,822,800**	**34,287,220**	**17,535,580**
4	Type I1_4	Rice; Upland crops (Squash, Water melon)	**18,830,000**	**14,352,180**	**4 477 825**
5	Type I2_1	Rice; Upland crops (Water melon)	**14,548,800**	**8 743 845**	**5 804 955**
6	Type I2_2	Rice; Upland crops (Water melon, Onion); Vegetables (Squash, Potato, Tomato); Fruit-tree (Longan, Litchi); animal husbandry (pig, chicken)	**52,068,640**	**33,465,490**	**18,603,150**
7	Type I2_3	Rice; vegetable (squash); upland crops (Sweet potato, Onion); Fruit-tree (Longan); Animal husbandry (Pig)	**15,559,660**	**11,101,170**	**4 458 494**
8	Type I2_4	Rice; upland crops (Water melon, Onion); Animal husbandry (Pig, Fish pond)	**107,820,000**	**55,314,400**	**51,565,600**
9	Type I2_5	Rice; Water melon, Litchi; Pig, chicken	**58,196,200**	**34,078,380**	**24,117,820**
10	Type II_1	Rice; Pig	**21,326,200**	**13,604,380**	**7 721 822**
11	Type II_2	Rice, Onion; Pig	**31,960,000**	**20,929,800**	**11,030,200**

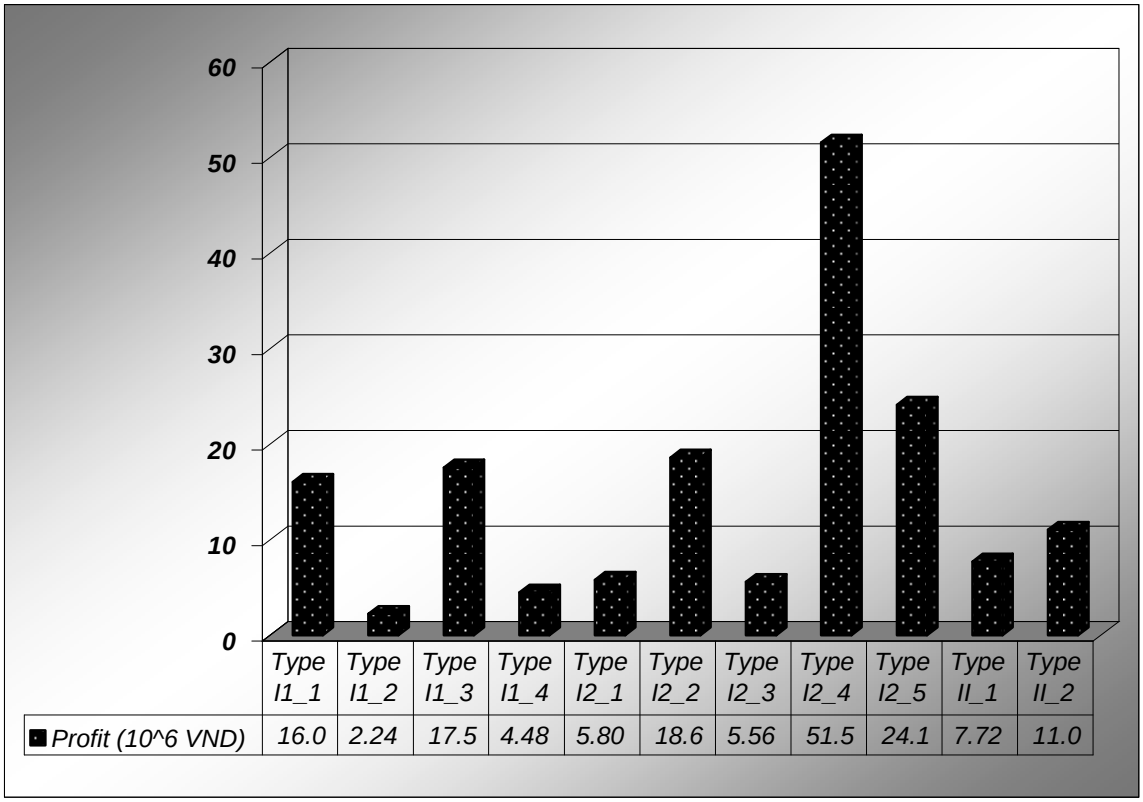


Fig 4.3 Profit of farmers' types in Hop Tien (10^6 VND)

The figure shows that farmer's type I2_4 (Rice; water melon, onion, pig, fish pond) gets highest production profit; meanwhile, the type I1_2 (Rice, squash, onion, longan, chicken, goose) gets the lowest profit

Type I2_4 bring out the biggest profit, however, it also need the highest investment compares with other farmer type. (Appendix C table C1)

The highest profit (**51,565,600 VND)** is 23 higher than the lowest profit of type I1_2 (2,239,451). This caused by type I2_4 gets the big income from animal husbandry.

To find the most suitable model of farmer we basing on the margin profit per one land density (1 land density = 1 sao = 360m2). (The income gets from production in one unit of land)

Table 4.28 Profit per one land density of different farmers' types in Hop Tien

Current unit: VND

No	**Farmers' types**	**Cropping styles**	**Margin profit/one land density (1sao)**
1	Type I1_1	Spring rice, Summer rice, Onion	**332,416**
2	Type I1_2	Spring rice, Summer rice, Squash, Onion, Longan	**257,472**
3	Type I1_3	Spring rice, Summer rice, Corn, Squash, Water melon	**237,581**
4	Type I1_4	Spring rice, Summer rice, Squash, Water melon	**263,401**
5	Type I2_1	Spring rice, Summer rice, Water melon	**416,424**
6	Type I2_2	Spring rice, Summer rice, Squash, Potato, Tomato, Water melon, Onion, Longan, Litchi	**388,164**
7	Type I2_3	Spring rice, Summer rice, Squash, Sweet potato, Onion, Longan	**254,396**
8	Type I2_4	Spring rice, Summer rice, Water melon, Onion	**406,900**
9	Type I2_5	Spring rice, Summer rice, Water melon, Litchi	**446,946**
10	Type II_1	Spring rice, Summer rice	**285,875**
11	Type II_2	Spring rice, Summer rice, Onion	**308,680**

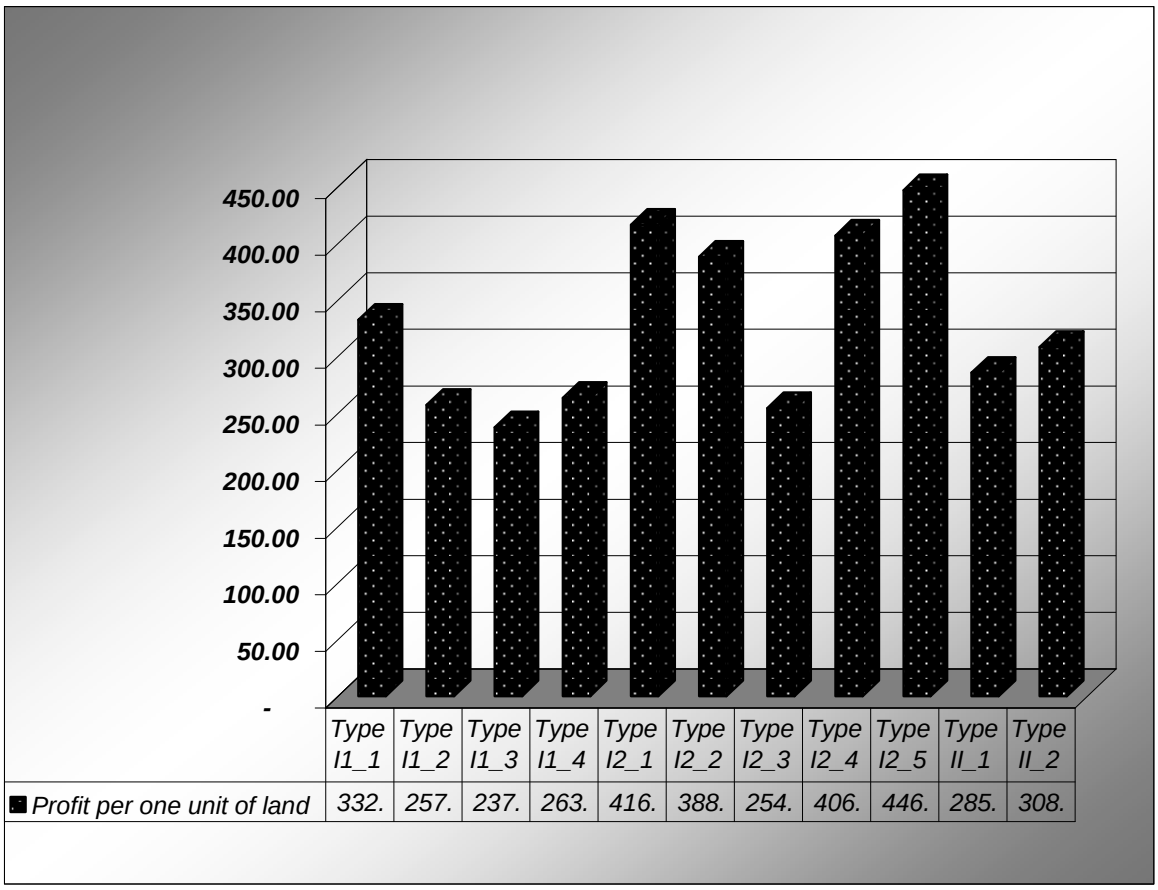


Fig 4.4 Profit per one unit of land of different farmers' types in Hop Tien (10^3 VND)

Cropping style I2_5 (Rice, water melon, litchi) get highest profit, follows by type I2_1 (rice, water melon), and the lowest profit belong to type I1_3 (rice, corn, squash, water melon).

Type I2_5 get highest profit per one land density, however, it do not have much income from animal husbandry. Type I1_1 gets the fifth position of profit per one land density but it occupies the first place of margin income of farmer, this caused by the income from animal husbandry (pig).

The highest income is 1.88 times higher than the lowest income from type I1_3.

HAZARD

Test different kind of hazard

Scenario 1: Rice crisis

As forecast by the World Food and Agriculture organization (FAO), the price of rice in 2008 reach the top so for following years, the rice price keep the same or having trend go down.

According to Dr. Nguyen Dinh Bich (2009), department of commerce and industry of Vietnam, one of there scenarios that can happen in 2009 is the rice price has trend decrease

40% compare with the top rice in 2008. Here, we test the first scenario with rice price reduces 40%.

Scenario 2: The increase of input price for production like the rise of fertilizer price

As in a prediction (March, 2009) of Vietnam Trade promotion Agency (Website: http://www.vietrade.gov.vn/index.php?option=com_content&task=view&id=4985&Itemid=280), the price of fertilizer in 2009 increases by 10% compare with the price in 2008. So, the second scenario makes with fertilizer price increase by 10%.

Scenario 3: The fluctuation of product yield (rice yield; vegetable yield)

Table 4.29 Fluctuation of rice yield between years from 1985 to 2008

No	Year	Rice yield (ton/ha)	No	Year	Rice yield (ton/ha)
1	**1985**	**4.07**	13	**1997**	**5.818**
2	**1986**	**3.286**	14	**1998**	**5.652**
3	**1987**	**2.225**	15	**1999**	**5.674**
4	**1988**	**4.109**	16	**2000**	**5.911**
5	**1989**	**4.071**	17	**2001**	**2.85**
6	**1990**	**3.503**	18	**2002**	**6.081**
7	**1991**	**1.5**	19	**2003**	**6.273**
8	**1992**	**4.04**	20	**2004**	**6.374**
9	**1993**	**4.618**	21	**2005**	**6.382**
10	**1994**	**5.015**	22	**2006**	**6.443**
11	**1995**	**4.999**	23	**2007**	**5.84**
12	**1996**	**5.592**	24	**2008**	**6.94**

Source: Hai Duong statistical yearbook from 1985 to 2008

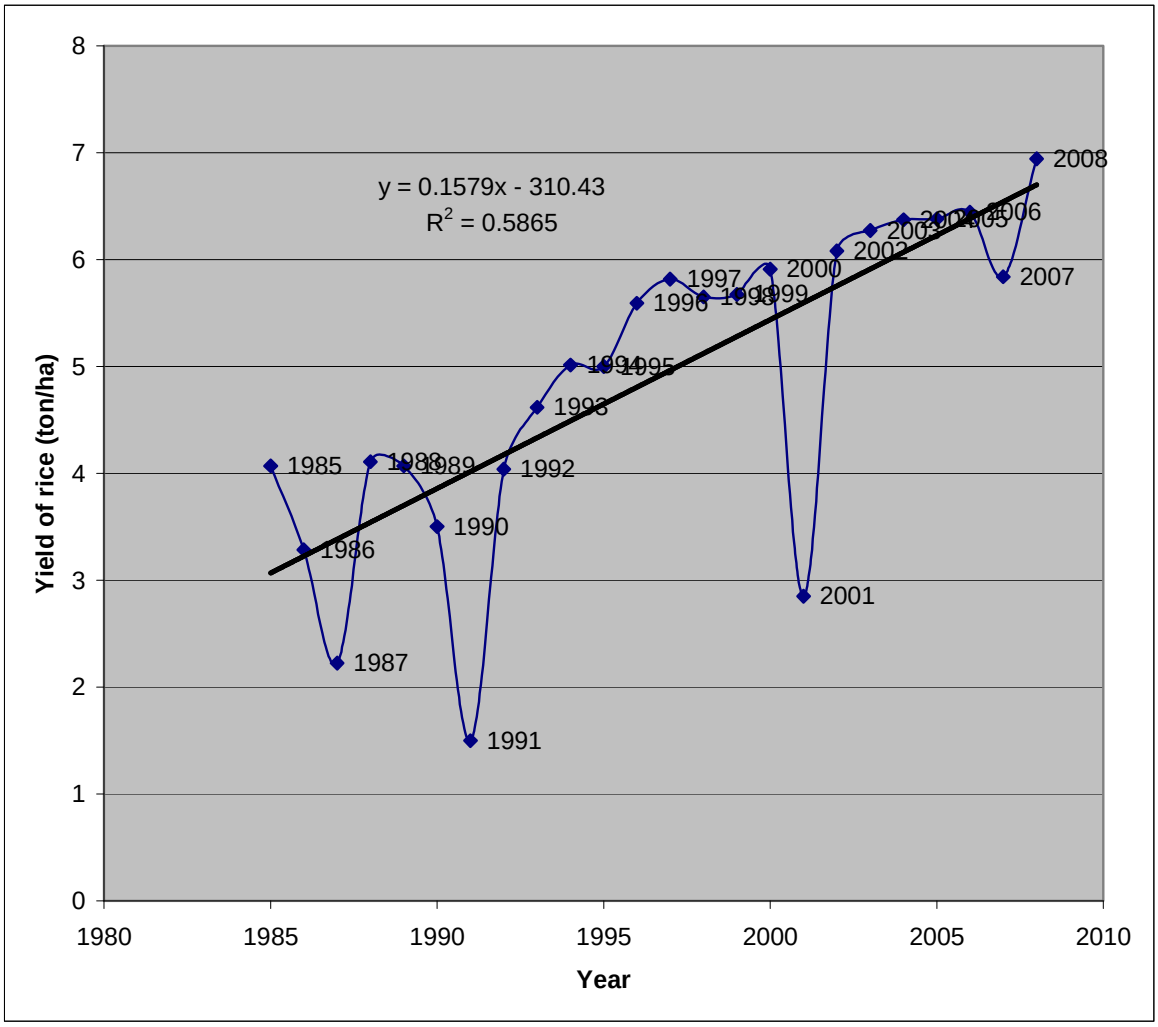


Fig 4.5 The fluctuation of Rice yield from 1985 to 2008

Basing on the above result we assume the rice yield for following years by using the linear equation, based on the change of rice yield from 1985 to 2008

Table 4.30 Estimated rice yield in the period from 2009 to 2015

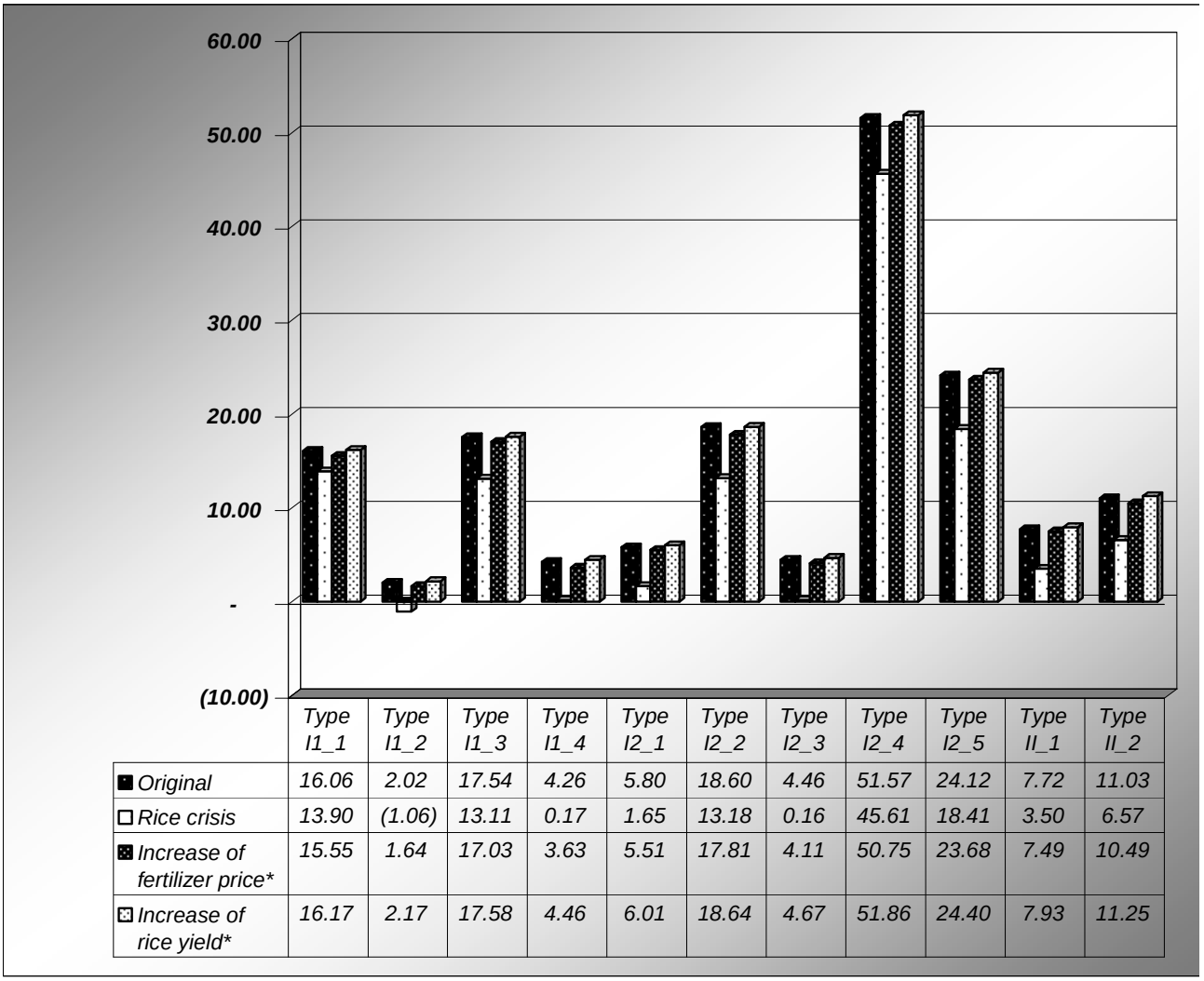
Year	Yield ton/ha	Convert to kg/sao
2009	6.79	244.28
2010	6.95	249.96
2011	7.11	255.64
2012	7.26	261.32
2013	7.42	267.00
2014	7.58	272.68
2015	7.74	278.36

The third scenario is done for rice yield in 2009 is 6.79 ton/ha increase 2% compare with this in 2008

Table 4.31 Profit of different types of farmers in Hop Tien according to the change of scenarios in Hop Tien

Unit: VND

Farmers' types	Original*	Scenario 1		Scenario 2		Scenario 3	
		Rice crisis	Decrease rate of profit (%)*	Increase of fertilizer price*	Decrease rate of profit	Increase of rice yield*	Increase rate of profit
Type I1_1	16,057,680	13,900,080	13.44	15,548,940	3.17	16,165,560	0.67
Type I1_2	2019451	-1,060,709	**152.52**	1,644,090	**18.59**	2,173,459	**7.63**
Type I1_3	17,535,580	13,107,460	25.25	17,026,080	2.91	17,583,730	0.27
Type I1_4	4257825	165,825	**96.11**	3,626,035	**14.84**	4,462,425	**4.81**
Type I2_1	5804955	1,653,435	71.52	5,505,688	5.16	6,012,531	3.58
Type I2_2	18,603,150	13,175,150	29.18	17,807,840	4.28	18,643,550	0.22
Type I2_3	4458494	158,174	**96.45**	4,108,064	7.86	4,673,511	**4.82**
Type I2_4	51,565,600	45613600	11.54	50748400	1.58	51863200	0.58
Type I2_5	24,117,820	18411340	23.66	23678230	1.82	24403150	1.18
Type II_1	7,721,822	3503342	54.63	7485384	3.06	7932746	2.73
Type II_2	11,030,200	6566200	40.47	10489150	4.91	11253400	2.02



	Type I1_1	Type I1_2	Type I1_3	Type I1_4	Type I2_1	Type I2_2	Type I2_3	Type I2_4	Type I2_5	Type II_1	Type II_2
Original	16.06	2.02	17.54	4.26	5.80	18.60	4.46	51.57	24.12	7.72	11.03
Rice crisis	13.90	(1.06)	13.11	0.17	1.65	13.18	0.16	45.61	18.41	3.50	6.57
Increase of fertilizer price*	15.55	1.64	17.03	3.63	5.51	17.81	4.11	50.75	23.68	7.49	10.49
Increase of rice yield*	16.17	2.17	17.58	4.46	6.01	18.64	4.67	51.86	24.40	7.93	11.25

Fig 4.6 The trend of profit of farmers' types in Hop Tien with three different scenarios (Rice price, fertilizer price and rice yield) (10^6 VND)

The results in table or figure show that the farmer's type I1_2 get the most effect by the change of different scenarios.

4.8.3 The results of Gia Xuyen commune

Likewise in Hop Tien, we test for the type I (Full time farmer with different cropping systems: type I1, I2, I3, I4, I5), type II (Full time farmer with production system: fish pond) and type III (part time farmer with horticultural activities).

Table 4.32 Economic results of farmer's types in Gia Xuyen

Unit: VND

No	Farmers ' types	Production styles	Total product income	Total operation cost	Margin (or profit)
1	Type I1	*Spring rice, summer rice*	9 250 560	5 787 831	3,462,730
2	Type I2	*Spring rice, water melon, summer rice, potato*	23,922,000	9 814 880	14,107,120
3	Type I3	*Spring rice, water melon, winter vegetable*	57,522,100	10,252,730	47,269,370
4	Type I4	*Spring rice, soybean, special onion*	11,540,160	10,740,620	799,545
5	Type I5	*Spring rice, summer rice, winter vegetable*	31,857,820	7 292 089	24,565,730
6	Type II	*Fish pond, animal husbandry, grass for fish*	955,579,500	790,440,000	165,139,500
7	Type III	*Peach flower*	142,759,600	39,643,430	103,116,200

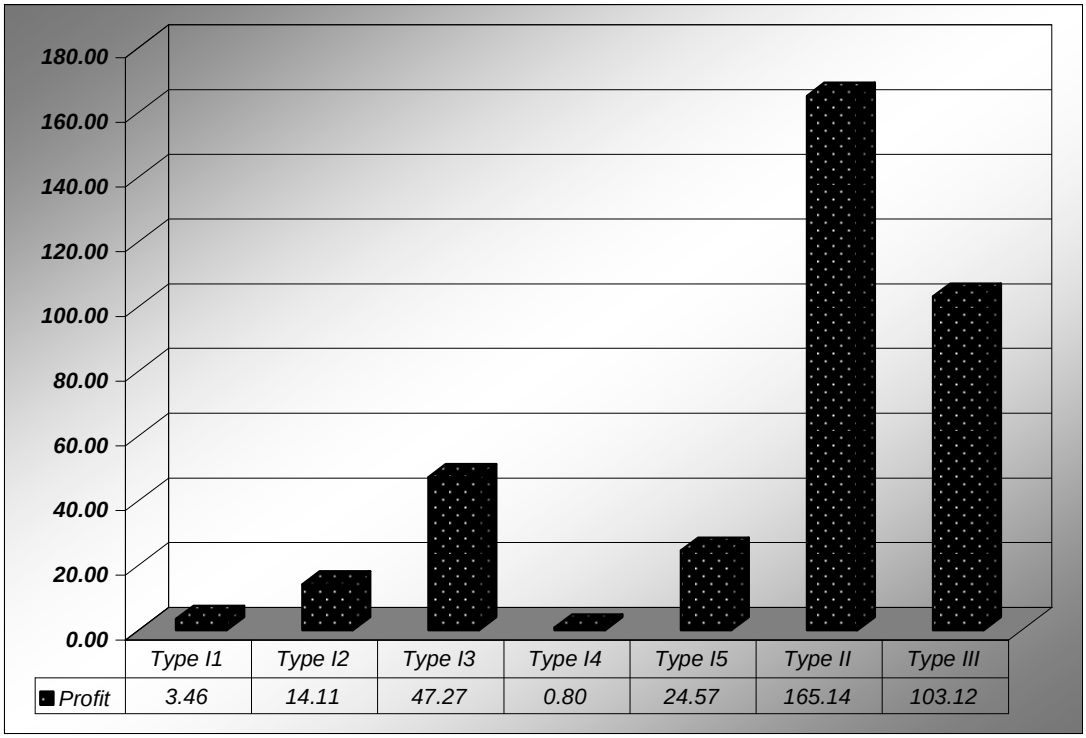


Fig 4.7 Profit of different farmers' types in Gia Xuyen (10^6 VND)

As can be seen that the farmer **type II** (Fish pond, animal husbandry, grass for fish) gets the highest benefit, in contrast, the type I4 (Spring rice, soybean, special onion) is in the lowest position of seven farmers' types about the profit in production

The benefit of highest type (165,139,500 VND) is much higher than the lowest type (799,545 VND) is 207 times. However, to implement this type we need the high initial investment and the knowledge about fish husbandry or the knowledge about horticulture.

For different cropping styles of farmer type I, we see the profit per one land density of type I1 to type I5

Table 4.33 Margin profit per one land density of different farmers' types in Gia Xuyen

Current unit: VND

No	Farmers' types	Cropping styles	Margin profit/one land density*(1sao)
1	Type I1	*Spring rice, summer rice*	393,492
2	Type I2	*spring rice, water melon, summer rice, potato*	854,977
3	Type I3	*Spring rice, water melon, winter vegetable*	2,708,370
4	Type I4	*Spring rice, soybean, special onion*	64,479
5	Type I5	*Spring rice, summer rice, winter vegetable*	1,949,661

(Note: One land density = 1 sao = 360 m2)

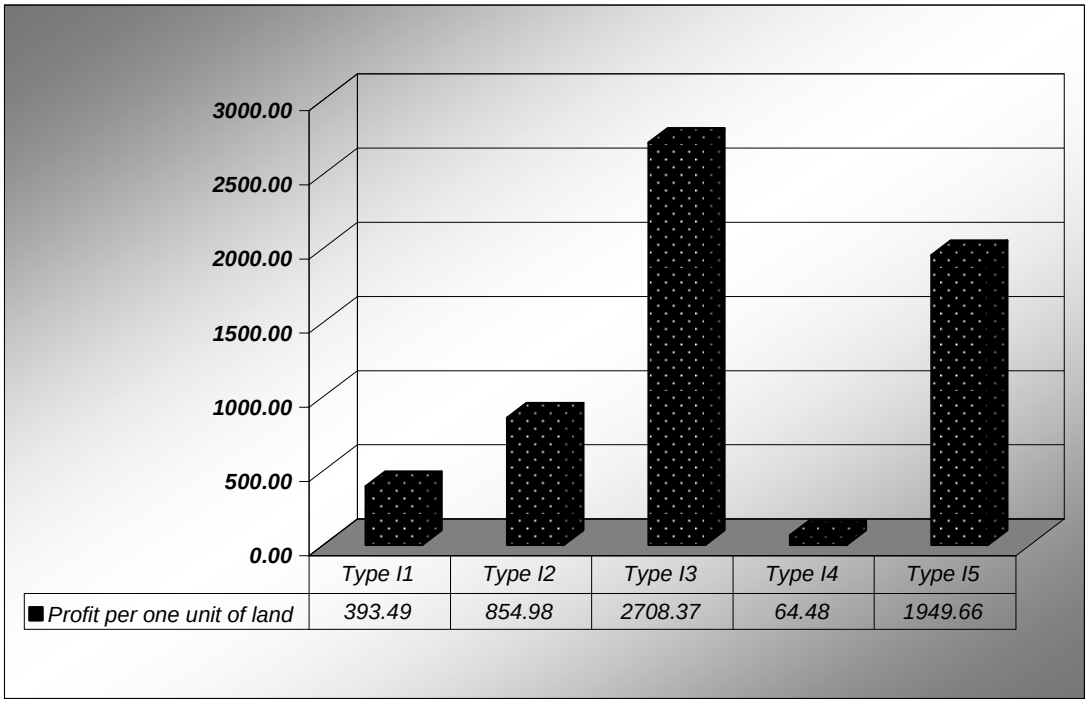


Fig 4.8 Profit per one unit of land in Gia Xuyen (1 unit land = 1 sao = 360 m2) (10^3 VND)

Type I3 (spring rice, water melon, winter vegetable) gets highest profit, followed by type I5 (spring rice, summer rice, winter vegetable) is in the second position, unlike type I3, I5, type I4 has the lowest margin

Margin of some kinds of crop of farmer type I3

In type I3, we analysis and find out the profit per one land density of different crops to determine the crop that brings out the highest margin and we have the result as follows:

Table 4.34 Profit of different crops in Gia Xuyen

Rank	Crops' name	Product	Expenses	Margin	Margin per one land density*
1	Cabbage	30,828,000	1,284,500	29,543,500	8,050,000
2	Water melon	5,010,000	879,255	4,130,745	2,473,500
3	Pear shape melon	4,800,000	833,000	3,967,000	1,983,500
4	Cauliflower	3,006,000	693,050	2,312,950	1,385,000
5	Kohlrabi	3,600,000	844,600	2,755,400	1,377,700
6	Cucumber	1,206,000	392,955	813,045	1,213,500
7	Tomato	614,725	243,746	370,979	553,700
8	Spring rice	5,206,392	2,916,398	2,289,994	528,867
9	Soybean	130,977	82,335	48,642	147,400

Cabbage is the kind of crop gets the highest profit per one land density and follows by the water melon, pear shape melon and the crop gets the lowest benefit is soybean, however, the most important here, soybean is kind of crop can supply nutrition and improve the quality of land. So, when the land is cultivated with high intension, some kind of crops like soybean should be planted to increase soil fertility.

Rice is the main crop in this area and also in Hop Tien, however, it is mostly used for self-consumption of farmer and the main source of income for farmers here is from other crops such as: cabbage, water melon and other kinds of vegetables

Type II, and Type III get the highest income from products but the expenses for production is also high, beside that it need advance knowledge, high investment..

Sensitivity analysis

Similarly, we test with three different scenarios: Rice price decrease 40%, fertilizer price increase 10% and the rice yield increase 2%

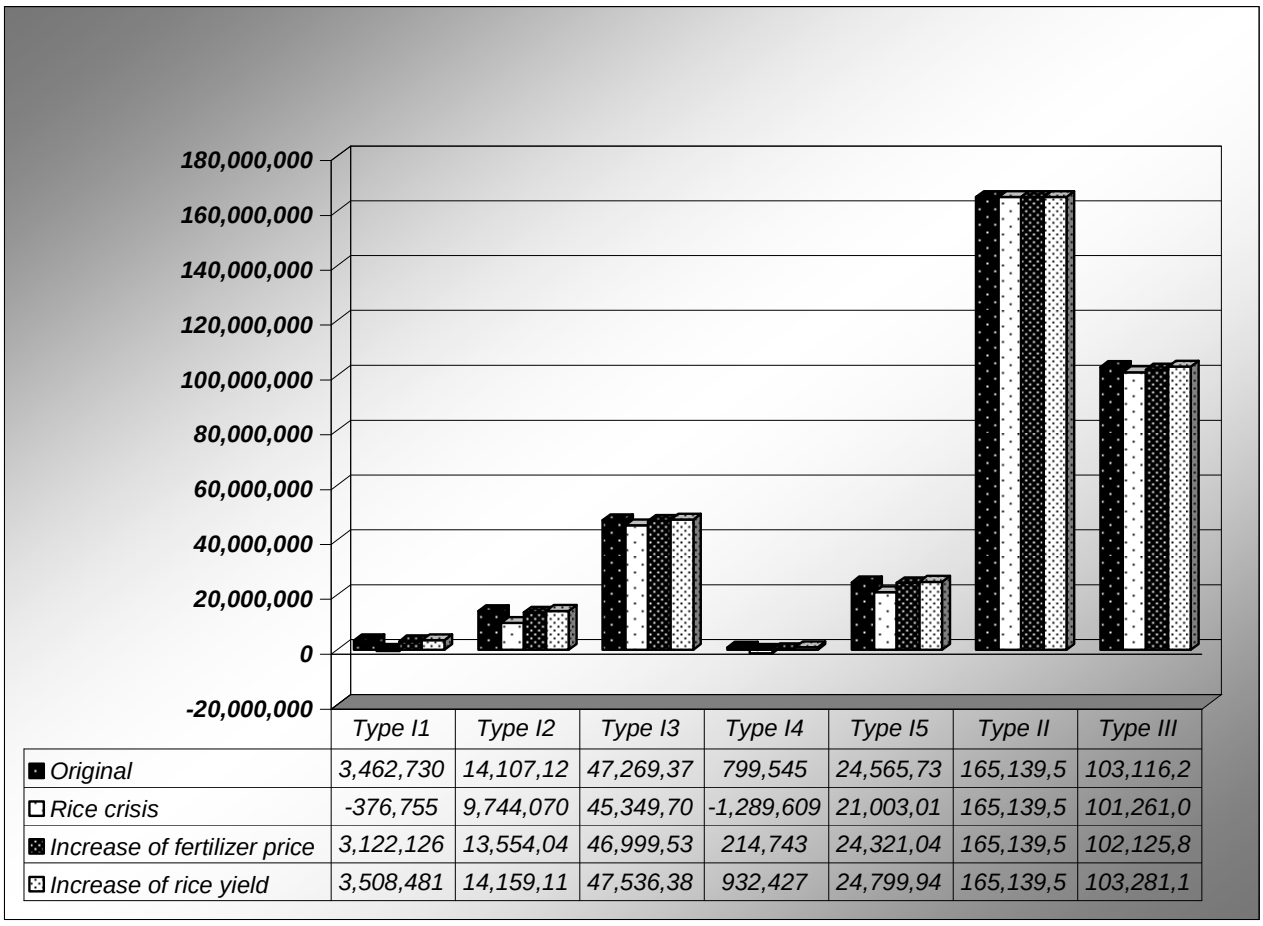
Table 4.35 Profit of different types of farmers in Gia Xuyen according to the change of scenarios

Farmers' types	Original*	Scenario 1		Scenario 2		Scenario 3	
		Rice crisis*	Decrease rate of profit (%)	Increase of fertilizer price**	Decrease rate of profit	Increase of rice yield***	Increase rate of profit
Type I1	3,462,730	-376,755	110.88	3,122,126	9.84	3,508,481	1.32
Type I2	14,107,120	9,744,070	30.93	13,554,040	3.92	14,159,110	0.37
Type I3	47,269,370	45,349,700	4.06	46,999,530	0.57	47,536,380	0.56
Type I4	799,545	-1,289,609	**261.29**	214,743	**73.14**	932,427	**16.62**
Type I5	24,565,730	21,003,010	14.50	24,321,040	1.00	24,799,940	0.95
Type II	165,139,500	165,139,500	0.00	165,139,500	0.00	165,139,500	0.00
Type III	103,116,200	101,261,000	1.80	102,125,800	0.96	103,281,100	0.16

(*Note:* * the rice price decrease 40% compare with the price in 2008*

*** The fertilizer price increase 10% compare with it in 2008*

**** The rice yield in 2009 increase 2% compare with it in 2008)*



	Type I1	Type I2	Type I3	Type I4	Type I5	Type II	Type III
Original	3,462,730	14,107,12	47,269,37	799,545	24,565,73	165,139,5	103,116,2
Rice crisis	-376,755	9,744,070	45,349,70	-1,289,609	21,003,01	165,139,5	101,261,0
Increase of fertilizer price	3,122,126	13,554,04	46,999,53	214,743	24,321,04	165,139,5	102,125,8
Increase of rice yield	3,508,481	14,159,11	47,536,38	932,427	24,799,94	165,139,5	103,281,1

Fig 4.9 The trend of farmers' profit in Gia Xuyen with three different scenarios (rice price, fertilizer price, rice yield) (VND)

The results show that the profit of farmer type I4 (spring rice, soybean, special onion) is affected significantly by given scenarios. In contrast, type III and type I3 is affected less by the increase or decrease of price. Type II (fish pond) is not affected by the change of rice price or fertilizer. Type I4 brings out lowest benefit but it has the considerable influence by the change of price so we should change this model to other cropping system styles

4.9 Discussion the results

4.9.1 Comparison between two communes

Table 4.36 Comparison between two communes

Items	Gia Xuyen commune	Ho Tien commune
General different information between two communes	- The irrigation system in Gia Xuyen supplies water for 194 ha through the Quan Phan pumping station. - In Gia Xuyen there are more than 90% of the income sources come from agricultural production (crop diversification)	- The irrigation system in Hop Tien supplies water for 363 ha through three pumping stations: Cau Chua, Hop Tien and Chua Buom - In Hop Tien: the income sources are integration of non-farm income, crop and animal feeding.
Crop diversification	- Cropping system styles (different crops such as rice, upland crop, winter crop, peach flower, fish pond) - Cropping intensity (360%)	The integration of rice, winter crops and animal husbandry Crop intensity (243%)
Livelihood pattern	- Full time farmer (85%), part time farmer (6%) and non farm farmer (9%) - The farmer is specialized into two types with one type only cultivate alternative crop styles, and the other type with only animal husbandry (fish pond, pig feeding)	- Full time farmer (58%), part time farmer (30%) and non farm farmer (12%) - Most farmers here produce with the integrated model of crop and animal husbandry. The contribution percentage of crop, animal and non-farm job to total income of farmers in Hop Tien are crop income (25%); animal husbandry income (33%) and non-farm income (42%)
Factors explaining in crop diversification and livelihood patterns	For livelihood patterns - **Age of head person** in household* - Family size - **Elevation of household's farm land*** - **Cropping system styles*** - Size of land holding - Intention for diversification	For livelihood patterns - **Farming expertise of head person in household*** - Number of farm labor in household - Size of land holding of each family - Different kinds of livestock feeding - Rice yield - Intention for diversification
	For crop diversification - **Cropping system styles*** - Location of farm land in the irrigation system - Amount of seedling used for one unit of land (1 sao = 360 m2) - Herbicide used for 1 crop - Potassium used for one unit of land	For crop diversification - **Cropping system styles*** - Farmer's intention about crop diversification - **Farmer's satisfaction with current situation of water distribution*** - **Potassium** used for 1 unit of land* - Location of farm land in irrigation system

4.9.2 Sensitivity analysis (building the scenarios of rice price and fertilizer price)

Rice price and fertilizer price

Year	Rice price (VND)
1998	2185
1999	1740
2000	1540
2001	2350
2002	2208
2003	2250
2004	2500
2005	2750
2006	2850
2007	3683
2008	4600

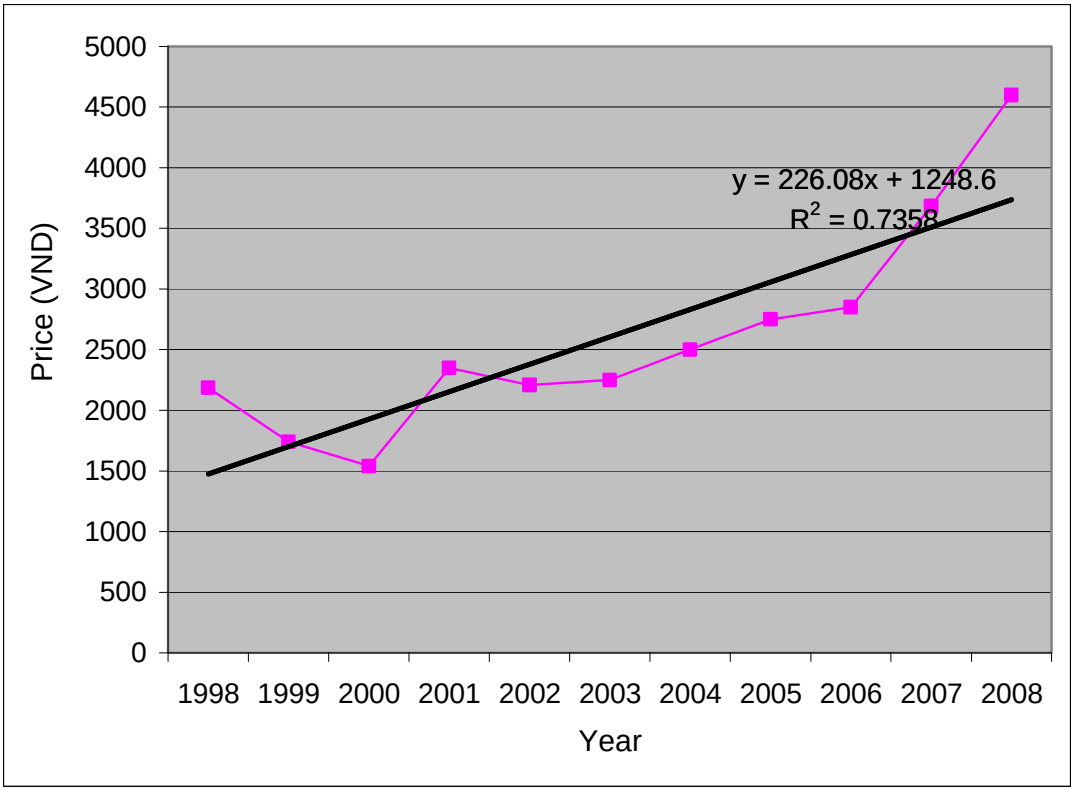


Fig 4.10 The trend of rice price in the period from 1998 to 2008

As this graph shows the rice price has increase in next years. The rice price depends upon many factors like: the export condition of country exporting rice, the demand for importing from other countries, etc. Many scenarios that can happen in the futures; however, the local experts in this region forecast the rice price in 2009 decreases 40% compares with the top rice price in 2008. So the scenario rice price decrease 40 percent is focused to highlight the sensitivity level of farmers' types.

Fertilizer price

Year	Fertilizer (VND)
1998	2140
1999	1888
2000	2016
2001	2350
2002	2200
2003	3400
2004	4000
2005	4650
2006	4750
2007	5150
2008	9500

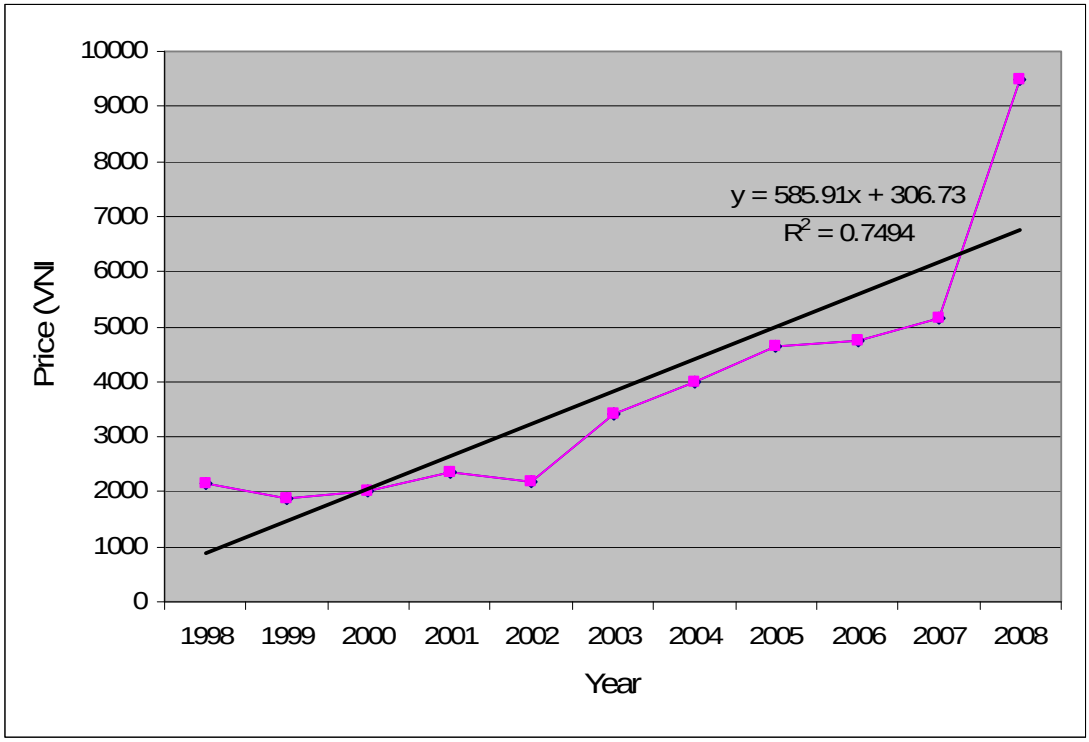


Fig 4.11 The trend of fertilizer price from 1998 to 2008

Similarly, for fertilizer price the figure shows the dramatic increase in the period from 2007 to 2008 (85%). In this research the scenario for 2009 the fertilizer rice increases 10% compared with price in 2008 is invested.

4.9.3 Summary farmer's type in Gia Xuyen and Hop Tien

The farmers' types in op Tien and Gia Xuyen are developed used criteria about main income and cropping system styles

Table 4.37 Farmers' types in Hop Tien

Hop Tien commune		
Farmer's type	**Farmers' subtypes divided by cropping system styles**	**Cropping styles**
Type I1 (Full time farmers and income is complemented by non-farm income from other members	Type I1_1	Spring rice, Summer rice, Onion
	Type I1_2	Spring rice, Summer rice, Squash, Onion, Longan
	Type I1_3	Spring rice, Summer rice, Corn, Squash, Water melon
	Type I1_4	Spring rice, Summer rice, Squash, Water melon
Type I2 (Full time farmer get income only from agricultural production)	Type I2_1	Spring rice, Summer rice, Water melon
	Type I2_2	Spring rice, Summer rice, Squash, Potato, Tomato, Water melon, Onion, Longan, Litchi
	Type I2_3	Spring rice, Summer rice, Squash, Sweet potato, Onion, Longan
	Type I2_4	Spring rice, Summer rice, Water melon, Onion
	Type I2_5	Spring rice, Summer rice, Water melon, Litchi
Type II (Part time farmers)	Type II_1	Spring rice, Summer rice
	Type II_2	Spring rice, Summer rice, Onion

Table 4.38 Farmers' types in Gia Xuyen

Gia Xuyen commune		
Farmer's type	**Farmers' subtypes divided by cropping system styles**	**Cropping styles**
Type I (Full time farmer with different cropping system styles)	Type I1	Spring rice, summer rice
	Type I2	Spring rice, water melon, summer rice, potato
	Type I3	Spring rice, water melon, winter vegetable
	Type I4	Spring rice, soybean, special onion
	Type I5	Spring rice, summer rice, winter vegetable
Type II (full time farmers with aquacultural activities)	Type II	Fish pond, animal husbandry, grass for fish
Type III (Part time farmers with horticultural activities)	Type III	Peach flower

4.9.4 The crop diversification in Gia Xuyen and Hop Tien

Gia Xuyen

- Crop calendar in Gia Xuyen shows that the farmers in that commune cultivate more than 4 crops per years with the crop rotation as follows: spring rice (Feb- May); Water Melon (June-August); Early cabbage (September-October); Winter crops (November to January).

- The diversify of crop with high intensity (crop intensity =350%)

Hop Tien

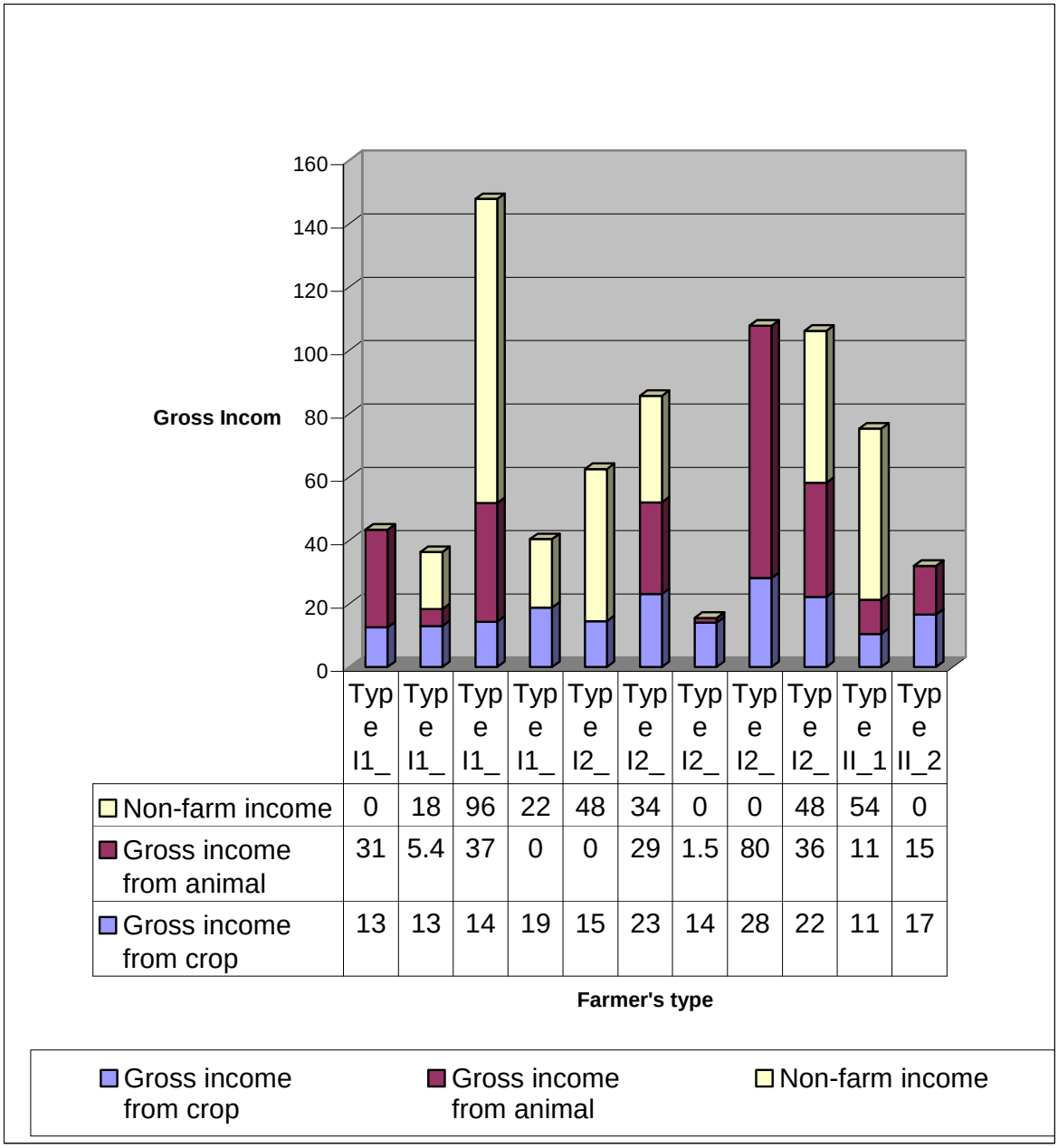
Hop Tien commune is a typical region in Red River delta by the diversification in livelihood patterns. The agricultural production is an integration of alternative crop cultivation (rice, onion, water melon) and animal husbandry (pig, fish, chicken)

Table 4.39 The income percentage of crop, animal and non-farm activities contributed to total family's income in Hop Tien

Unit (10^6 VND)

Farmer's type	Gross income from crop	Gross income from animal	Non-farm income	Total income
Type I1_1	12.594	30.8	0	43.394
Type I1_2	12.9704	5.355	18	36.3254
Type I1_3	14.3578	37.465	96	147.8228
Type I1_4	18.83	0	21.6	40.43
Type I2_1	14.5488	0	48	62.5488
Type I2_2	23.08864	28.98	33.6	85.66864
Type I2_3	14.01966	1.54	0	15.55966
Type I2_4	28.08	79.74	0	107.82
Type I2_5	22.2162	35.98	48	106.1962
Type II_1	10.5462	10.78	54	75.3262
Type II_2	16.56	15.4	0	31.96
Average	17.0737909	22.36727273	29.01818182	68.45924545
Percentage	**25**	**33**	**42**	**100**

(Here only the households have agricultural production are considered in calculation, the non- farmers in this commune are neglected)



	Type I1_	Type I1_	Type I1_	Type I1_	Type I2_	Type I2_	Type I2_	Type I2_	Type I2_	Type II_1	Type II_2
Non-farm income	0	18	96	22	48	34	0	0	48	54	0
Gross income from animal	31	5.4	37	0	0	29	1.5	80	36	11	15
Gross income from crop	13	13	14	19	15	23	14	28	22	11	17

Fig 4.12: The average percentage of crop, animal and non-farm activities contributed to total income of family (10^6 VND).

Most farmers in Hop Tien get the main income from the non-farm income (account for 42% total income of household). Because of the convenient location near high way and industry companies, so the people in Hop Tien work in industrial companies and get income **is higher than income from agricultural production.**

4.9.5 Summary farmers' performance

Gia Xuyen

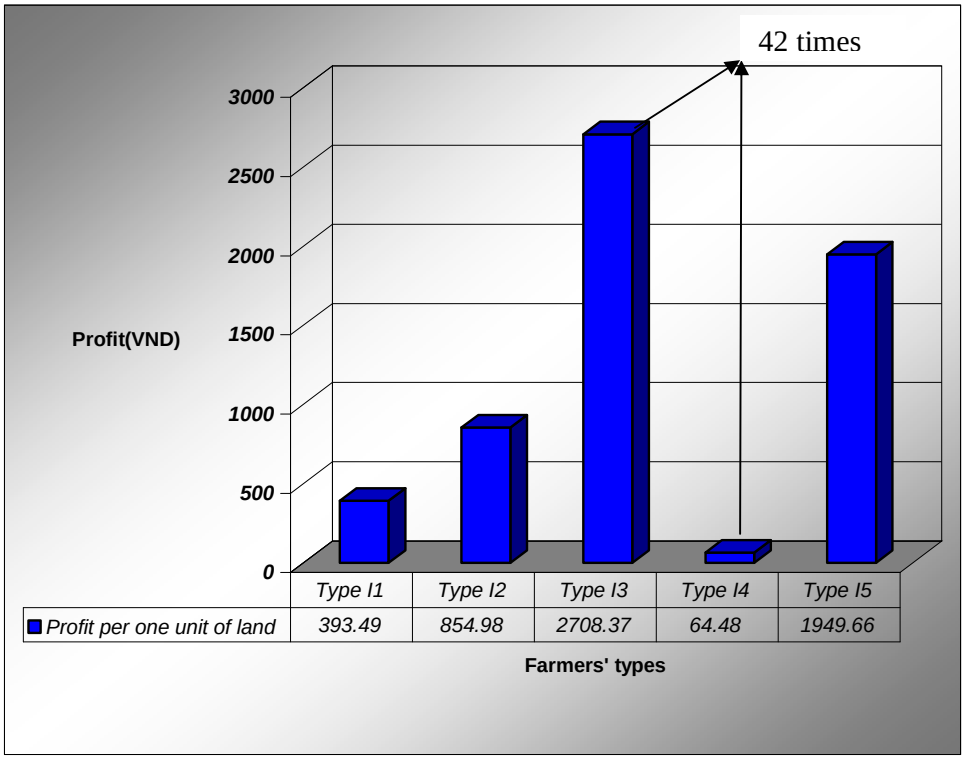


Fig 4.13 Profit per one unit of land in Gia Xuyen (10^3 VND)

The difference level between the farmer gets highest income (belonged to type II) and the farmer with lowest income is 42 times.

The farmer type II in Gina Xylem with the aqua cultural activities get highest profit, but the number households of this type is limited by these reasons:

- It is required a big size of land, but also each household only own small land size.
- The initial expenses (for small fish, food) are quite high so the farmer do not get enough money for this investment
- All farmers they occupy land in low elevation, they should change to this type and also the local authorities should training skills about aquaculture and have the support for farmers in the low land the capital loan with low interest rate.

The full time farmer with cropping system style: spring rice, water melon, winter crop (**type I3**) gets the highest, and cropping system style: spring rice, soybean, special onion gets the lowest profit (because the investment for fertilizer and seedling is quite high and the income from selling products is low, so the profit is low). It is necessary to shift from low value crops (soybean, special onion) in this region to higher value crops such as: cabbage, water melon, tomato.

Hop Tien commune

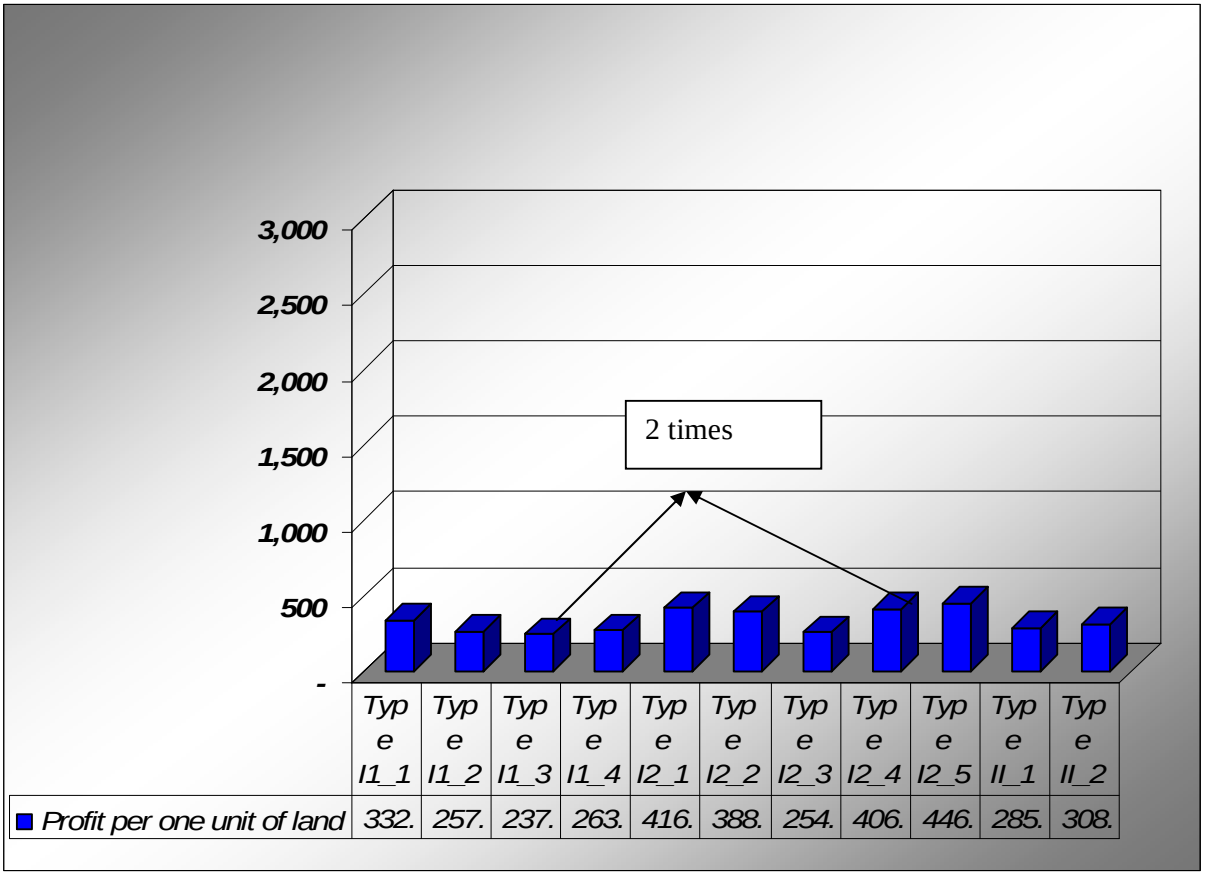


Fig 4.14 Profit per one unit of land of different farmers' types in Hop Tien (10^3 VND)

The difference level about profit per one unit of land between the farmer's types gets the highest profit and the farmer's type get the lowest profit is 2 times. This difference is non-significant compares with the difference in Gia Xuyen.

The farmers in Hop Tien they cultivate crops are quite similar, the profit between households is not far different and the difference in this commune comes from the other income sources such as: animal husbandry (pig, chicken, goose, fish) and non-farm income sources (workers, tailor, knitter).

In Hop Tien, the cultivation model with the integration of rice, water melon, onion, pig and fish pond showed the best performance.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The main objective of this research is the investigation into livelihood patterns and crop diversification of farmers' types. The finding of research shows the key factors that explain the diversification between households and their performance through the economic indexes. Case study is conducted in two communes Gia Xuyen and Hop Tien belong to the Red River Delta. The conclusion of this study can be summarized as follows:

Farmers' types were identified through the typological approach and they depict the general socio-economic and technical condition of households and their performances in case study region.

The households in Gia Xuyen are classified into five types: Type I (full time farmer with different cropping systems: 81.3%); type II (full time farmer with production system: fish pond (4.2%); Part time farmer with horticultural activities (type III, 5.2%); type IV (salaried employee: 6.2%) and the Self-employee (type V: 6.2%)

In the same fashion, households in Hop Tien are divided into four types: type I (full time farmer: 58%); type II (part time farmer: 30%); Self-employed (type III: 5%) and type IV (regular employee: 7%)

The full time farmer in Gia Xuyen they get income only from agriculture production is quite high. The rate of non-farmers compare with farmers is low.

The diversification in Gia Xuyen is characterized by the alternative cropping system and in Hop Tien is the integration model of crop and animal husbandry.

Key factors that explain the diversification of livelihood and cropping system in two communes are investigated through using principal component analysis

There are six dominant factors that explain the difference between farmers in Gia Xuyen (Age of head person in household, Number of people on each family (family size), Elevation of household's farm land, Cropping system styles, Size of land holding, Intention for diversification). Similarly, in Hop Tien, six key factors are: Farming expertise of head person in household, Number of farm labor in household, Size of land holding of each family, Different kind of livestock feeding, Rice yield and Intention for diversification).

The factor about cropping system style in Gia Xuyen it explains for the high difference level between households in cultivation (the high diversification in crop). In Hop Tien the diversification is represented by factor "different kind of livestock feeding", rice yield between farmers' types and the intention of farmers' types for crop diversification are also different.

Cropping intensity in Gia Xuyen is 359.83 percent (2008) higher 1.5 times than this in Hop Tien with 242.6 percent. The average water productivity of rice for whole irrigation system in Gia Xuyen is 4.01 (kg/ha.mm) = 0.401 (kg/m3). The high cropping intensity in Gia Xuyen implies the high diversification of crops.

Farmer's performance is shown by the economic indexes (profit, profit per one unit of land) with OLYMPE approach (socio-economic approach).

In Gia Xuyen type II (full time farmer with production system: fish pond) gets the highest profit (165,139,500 VND), meanwhile, type I4 (full time farmer with production system: spring rice, soybean, special onion) shows the lowest profit (799,545 VND). Furthermore, the cropping system (spring rice, water melon, vegetable) that has the highest profit per one land density (or 1 sao = 360 m2) is developed. The result also shows that cabbage is the kind of crop has the highest profit; in contrast, soybean is the less profit crop. For testing with three scenarios: Rice crisis (rice price reduce 40% compare with rice price in 2008); fertilizer price increase 10% and rice yield increase 2%, the result shows that type I4 (full time farmer with cropping style: spring rice, soybean, special onion) gets the highest sensitivity rate with these changes.

Similarly for Hop Tien, the full time farmer type I2_4 (rice, water melon, onion, pig, fish pond) reach the highest profit, in contrast, full time farmer type I1_2 (rice, squash, onion, longan, chicken, goose) performs the lowest profit.

For profit per one land density full time farmer type I2_5 (rice, water melon, litchi) show the highest profit and full time farmer type I1_3 (rice, corn, squash, water melon) get the lowest profit.

The full time farmer's type I2_4 get highest benefit but this type did not perform the highest profit per one unit of land. It is explained by the big amount of net income contributed from other products (here is animal product) to income of farmer. Though, they do not get highest profit per one land density from crop, they still get highest profit by cultivation system of integration of crop and animal.

These results imply that the higher income resources come from the diversification of diversified cropping system in Gia Xuyen or the integration of crop and animal in Hop Tien.

The salient feature that makes the difference between two communes is the Gia Xuyen with the diversification of crop style and Hop Tien is the integration of crop, animal and non-farm income

The crops: cabbage, water melon in Gia Xuyen and onion, tomato in Hop Tien are high-profit value crops.

The difference in profit between households in Gia Xuyen is 42 times, this is explained by the significant difference between aquacultural activities and crop cultivation models of households in GIa Xuyen. In Hop Tien is difference level is only 2 times, the similarity in cultivation models of households in Hop Tien is the reason for the little difference of households in Hop Tien.

5.2 Recommendation

From the findings of this research some suggestions are proposed as follows:

In Gia Xuyen

- The number of people participate in agricultural production is quite high (accounts for 91%) and they do not get income from other sources, so it is necessary to promote the farmers do other works (non-farm works) to heighten their income (such as the job: making rice vermicelli, husk rice) they also should invest into other non-farm works such as the traditional handicraft, knitter.

- The diversification in this commune is mainly based on alternative cropping styles, so the animal husbandry should be encouraged.

- The aquaculture model and the horticultural activities should be widened for whole households they occupies land in low elevation, however, it also need the big amount of initial capital and the big size of land. The local authorities should have policy to support for the farmers do those models like creating advantage conditions for farmers can have the bank credit with low interest rate.

- Widening the area for cabbage, tomato; that, have high profit values. The area for special onion, soybean should be narrowed.

- The different farmer's type in Gia Xuyen they use different amount of potassium, herbicides, and seedling for one land density of rice, so the agricultural production teams should organize the training for farmers in production techniques.

- With the intensified agricultural production as Gia Xuyen the exchange products is very important, the commercial people are encourage to purchase the farmers' products, this will reduce the delivery charge to market for farmer and also orient for farmers that they should cultivate to meet the market's demand.

Farmer

- Intensifying the experiment exchange between households. The farmers also learn about the production techniques, the market's demand through the mass media.

In Hop Tien

- The finding from economic analysis shows that the income from animal husbandry in this commune is quite high, so the large scale farmstead that specialized in animal husbandry should be broadened.

- The exchange products in Hop Tien is more difficult than in Gia Xuyen, because in this commune, there is no big markets for farmers can sell their products conveniently, so it is imperative need to encourage the commercial people in purchasing the farmers' products.

- Besides onion is main crop in the winter season, the farmers here should cultivate more other high profit value crops like: water melon, winter vegetables.

- The water distribution in Hop Tien should be improved; the main canal and the third canal should be concreted to reduce the water loss in delivery from main canal to field.

- **Further research**

- More other scenarios such as land use change, the increase or decrease of fertilizer used for crop, etc should be invested

- Developing other economic factors (profit per one labor, profit per one animal) to highlight the farmer's performance.

- Applying OLYMPE approach in the large scale to other regions not only in Red River but also in other ecological regions.

REFERENCES

Alther, C., Castella, J. C., Novosad, P., Rousseau, E., & T. T. Hieu. (2002). Impact of accessibility on the range of livelihood options available to farm households in mountainous areas of Northern Vietnam. *In Doi Moi in the mountains - Land use changes and farmers' livelihood strategies in Bac Kan Province, Vietnam.* Castella, J. C. et al. (ed.): 121-146. Hanoi, Vietnam: The Agricultural Publishing House.

Andrew, S. S, Mitchell, J. P., R., Karlen, D. L., Hartz, W. R., Pettygrove, G. S., Scow, K. M, an Munk, D. S. (2002). *On-farm assessment of soil quality in California's central valley. Agron.J.,94, 12-23*

Asian Productivity Organization (1991). *Agriculture Diversification – Report of a Study Meeting.* Tokyo: Author.

Asian Productivity Organization (2001). Water use efficiency in irrigation in Asia. In Pham Ngoc Hai. *Vietnam (pp224-232).* Tokyo: Author

Astel, A., Mazerski, J., Polkowska, Z., Namienik, J. (2004) Application of PCA and time series analysis in studies of precipitation in Tricity (Poland). *Adcance in Environmental research, Sciencedirect, 8(3-4), 337-349.*

Castella, J. C, et al. (2002). Doi Moi in the Mountains. Land use change and farmer' livelihood strategies in Bac kan province, Vietnam. The agricultural Publishing house, Hanoi, Vietnam, 1-18.

Castella, J. C., Tran Quoc Hoa, O. Husson, Vu Hai Nam, & Dang Dinh Quang. (2000). The declining role of ethnicity in farm household differentiation: Acase study from Ngoc Phai Commune, Cho Don District, Bac Kan Province, Viet Nam. In *Doi Moi in the Mountains: Land use changes and farmers' livelihood strategies in Bac Kan Province, Viet Nam,* ed. J. C. Castella and Dang Dinh Quang. Hanoi: Agricultural Publishing House.

CIRAD, INRA, IRD, IAMM, (2007). *OLYMPE Simulator for technical and economical modelling of farms.* Retrieved July 2008, from http://www.olympe-project.net.

Daskalopoulou, I., & Petrou, A. (2002). Utilising a farm typology to identify potential adopters of alternative farming activities in Greek agriculture. *Journal of Rural Studies, 18 (1), 95-103.*

Delgado, C., & Siamwalla, A. (1997). *Rural economy and farm income diversification in developing countries.* Discussion Paper No. 20. Markets and Structural Studies Division. Washington, D.C.:International Food Policy Research Institute.

Do Kim Chung. (1994). *Agricultural policy reform in Vietnam: Perspectives and implications for the Rice Economy.* (Doctoral dissertation No.AE-94-3, Asian Institute of technology, 1994). Bangkok: Asian Institute of technology.

Ellis, F. (1992). *Agricultural policies in developing countries*. Cambridge University Press.

Ellis, F. (1999). *Rural livelihood diversity in developing countries: Evidence and Policy implications.* Retrieved November 2008, from Overseas Development Institute Web site: http://www.odi.org.uk/resources/details.asp?id=2112&title=rural-livelihood-diversity-developing-countries-evidence-policy-implications.

Ellis, F. (2004). *Occupational Diversification in Developing Countries and Implications for Agricultural Policy.* Retried February 2009, from University of East Anglia Web site: http://www.oecd.org/dataoecd/25/9/36d562879.pdf

Ersado, L. (2003). *Income diversification in Zimbabwe: Welfare implications from urban and rural areas.* FCND Discussion Paper 152. Washington, D.C.: International Food Policy Research Institute.

Escobal, J. (2001). The determinants of nonfarm income diversification in rural Peru. *World Development 29 (3): 497–508.*

Fatoux, C., Castella, J. C., Zeiss, M., & Pham Hung Manh. (2002). From rice cultivator to agroforester within a decade: The impact of Doi Moi on agricultural diversification in a mountainous commune of Choi Moi District, BacKan Province, Viet Nam. In *Doi Moi in the Mountains: Land use changes and farmers'livelihood strategies in Bac Kan Province, Viet Nam*, ed. J. C. Castella and Dang Dinh Quang. Hanoi: Agricultural Publishing House.

Gia Xuyen irrigation enterprise (2008). *The pumping station operation handbook of Quan Phan pumping station.*

Girish, M. (2004). Crop diversification: AN empirical analysis of Kangra farms of Himachal Pradesh. *Agriculture Economics Research Review, 17 (2)*

Goletti, F. (1999). *Agricultural diversification and rural industrialization as a strategy for rural income growth and poverty reduction in Indochina and Myanma.* Retrieved December 2008, from International Food policy research Institute, MSS Discussion paper No.30. Web site: http://www.ifpri.org/divs/mtid/dp/papers/dp30.pdf.

GSO (General Statistics Office). (2007). *Hai Duong statistical Yearbook 2006.* Hanoi: Statistical Publishing house.

Henin, B. (2002). Agrarian change in Vietnam's northern upland region. *Journal of Contemporary Asia* 32 (1): 3–28.

Hop Tien & Gia Xuyen communes statistical departments (2008). *Annual statistical report.*

Kinh, N. N., Teng. P. S., Hoanh, C. T., & Castella. J. C. (1997). Towards an Eco-regional approach for Natural Resources Management in the Red River Basin of Vietnam. In Tuan, D. T., & Dung, L. T. C. *Agrarian systems and future scenarios for the Red River Delta.* (pp 243 - 254). Agricultural Publishing House – Hanoi, Vietnam.

Kurosaki, T. (2003). Specialization and diversification in agricultural transformations: The case of West Punjab, 1903–1992. *American Journal of Agricultural Economics 2: 373–387.*

Minot, N., et al (2006). *Income diversification and poverty in the Northern Uplands of Vietnam.* Retrieved March 2009, from International food policy research institute Washington, DC. Research report 145. *Web site: http://books.google.com/books?hl=vi&lr=&id=hPsqPU-7Jy0C&oi=fnd&pg=PP9&dq=Henin,+2002,+lang+son&ots=KsjaKLJArO&sig=obGI1Tfg5TVcNx4P55Od5pdIJSc#PPP1,M1*

Neupane, K. P.(2008). *Integrated analysis of smallholder irrigation sustainability in Nepal: A case study of the interplay between individual performances and collective action.* (Masters research study No WM-07-8, Asian Institute of Technology, 2008). Bangkok: Asian Institute of Technology.

Nguyen Dinh Bich (2009). *Rice price in 2009*. Retrieved March 2009, from Vietnam Chamber of Commerce and Industry Website: http://www.vcci.com.vn/doanh-nghiep/gia-gao-2009-coi-chung-roi-tu-do.

Nguyen Van Luat. (2001). *Crop diversification in Viet nam.* Retrieved November 2008, from http://www.mekongriver.org/cropdivn.htm.

Norusis, Marija J (1988). *The SPSS guide to data analysis for SPSS^X*. Rush-Presbyterian-St.Luke's Medical Center.

Pallant, J. (2005). *SPSS survival manual: A step by step guide to data analysis using SPSS for Windows (Version 12, second edition).* Open University press

Pederson, G., & Annou, M. **(1999)**. Rural household income diversification in VietNam. *Quarterly Journal of International Agriculture* 38 (2): 140–149.

Perret, S. R., & Kirsten, J. F. (2000). *Studying the local diversity of Rural Livelihoods systems: An application of Typological techniques for Integrated rural development support in the Eastern cape (South Africa).* Retrieved December 2008, from University of Pretoria, Department of Agricultural Economics, Extension and Rural development Web site: http://ageconsearch.umn.edu/bitstream/18083/1/wp000005.pdf

Perret, S., Farolfi, S., Hassan, R. (2006). Water Governance for Sustainable Development. *Local Empowerment in Smallholder Irrigation Schemes: A methodology for Participatory Diagnosis and Prospective Analysis* (pp239-257).EARTHSCAN. London. Sterling,VA.

Schmitzberger, Th. Wrbka, B. Steurer, G. Aschenbrenner, J. Peterseil, & H. G. Zechmeister. (2005). How farming styles influence biodiversity maintenance in Austrian agricultural landscapes. *Agricultural, Ecosystems & Environment, 108 (3), 274-290.*

Tefera, T. L., et al (2004). Diversity in livelihoods and farmers' strategies in the Hararghe highlands, Eastern Ethiopia. *International Journal of agricultural Sustainability, 2(2), 133-146.*

Tran Chi Trung. (2005). *Evaluation of alternative irrigation management models in Vietnam.* (Doctoral dissertation No.WM-04-1, Asian Institute of technology, 2005). Bangkok: Asian Institute of technology.

Viet Nam national committee on large dams and water resources development. *(2007). Bac Hung Hai irrigation system.* Retrieved July 2008, from http://www.vncold.vn/Web/Content.aspx?distid=713

Zhen, L., Routray, J. K. (2003): Operational Indicators for measuring Agricultural sustainability in developing countries. *Journal of Springer, 32 (1), 34-46.*

APPENDIX A – QUESTIONNAIRES OLYMPE

Appendix 1 **QUESTIONNAIRE OLYMPE** Date:

REGION: N^0:

Scheme:

Name of head of household:

Gender: Male [ ] Female [ ]

Location:

Date of settlement:

1. **Household composition**

Members	**Age**	**Gender**	**Main occupation**
Head of household			
Spouse			
Children > 18			
Children < 18			
Children < 6			
Other (e.g. Grand Parents, Grand children)			

2. **Land tenure**

Type of plot (dry land, irrigated land, garden)	**Size**	**Unit**	**Tenure system** **(**shareholding, freeholding,borrowing)

- Total farm area of your plots in the scheme?

- Do you pay any fees for land? Yes [ ] No [ ]

  If yes, how much per ha? To whom? ……

- Do you pay any fees for water? Yes [ ] No [ ]

  If yes how much per ha? ……

Cropping systems

Perennial crops

Plot	**Crop**	**Number of crop/Area**	**Age of crop (life-span)**

Annual or Seasonal Crops

Plot	**Crop**	**Months**	**Area or total size**	**Irrigated or not**

Fallow land

Plot	What done before?	Total area	Dates of last cropping

- Which crops are grown mainly for family consumption (thus hardly sold)? ……..
- What problems have you got with crop production in the scheme? ……..

Production

Crop	Area	Quantity/ha	Total Quantity	Dates of sale	Price (market)	Total income	Cash income

Charges

Activities	How many times	Dates	Duration	Family labor	Paid labor (external)	Total number of labor	Paid money	Price	Total

Inputs: (Seeds, fertilizer, herbicides, pesticides, equipment, consumables, etc.)

Operation	How many times	Dates	Type	Quantity/ha	Total quantity	Price	Total Price

Cash income

Off- farm Income*	Times/Dates	Salary/Amount

** The off-farm income include out side farm activities: hunting, fishing collection, processing, handicraft, loan repayment, subsidies.*

Cash expenditures

Loan/Debt Repayment	Timing/dates	Amount

Family expenditure

Type	Timing/dates	Amount

Family expenditures (not allocated to specific crop or system): Food, health, education, leisure, clothes, and welfare, exceptional expenditures, loan repayment, taxes, financial costs (repayments, interests).

- What problems have you got about input supply?.....
- Do you own any large equipment (e.g. tractor, implements) Yes / No

If yes, which?.....

- Do you hire them out? Yes [ ] No [ ]
- At which price?.....

How much do you earn from that hiring out (on average)?.....

Crop Calendar

Crop name	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec

Livestock description

Types	**Number currently owned**	**Origins**	**Purchasing Price**	**Saling Price**

- Number and type of animal slaughtered for family purpose last year? ……
- Where are they grazing? On the scheme? Yes [ ] No [ ]
- Any problem with livestock?.....

Structural costs (not allocated to a specific crop)

Machinery, labor, building, infrastructure, equipment

Type	Timing	Cost
Plot (purchase or rental)		
Orchard creation		
Building		
Equipment		

Finances

- Do you hire people for farming? Yes [ ] No [ ]

If yes, how much did you pay per year per ha? …….

- Have you got other sources of income in the household? (E.g. pension, remittances, wages, salaries, grant)

If yes, from whom? ……..

How much per month? …….

Are you using credit facility? Yes [ ] No [ ]

If yes, what was the source of the loan?

[ ] supplier

[ ] relative or friend

[ ] money lender

[ ] output buyer

[ ] Financial institution: …….

[ ] Other

What was it for?

[ ] Farming

[ ] general maintenance/ household purchases

[ ] For food

Have you got any debts outstanding? Yes [ ] No [ ]

Scheme Management

Do you experience problems or conflicts about water sharing?

Do you experience water shortages?

Never [ ]

Sometimes [ ]

Often [ ]

Always [ ]

In the frame of an improved water supply and water related services, how much would you be ready to pay/ha/year for such supply and services?

[ ] a given amount per year per ha

[ ] an mount depending on your farm income

In your opinion, if farmers had to pay, who should pay for water services?

[ ] Everyone in the scheme should pay for water services, regardless of what he/she does

[ ] The ones that are making money

[ ] The ones who are irrigating

[ ] Ones who are irrigating a lot

[ ] None/ only the government

Water User's Association and management committee:

Do you know about these structures?

Do you know the chairmen?

Any opinion on that?

Concluding the interview

What are your major problems?

As a beneficiary of the scheme?

As a member of the community?

What proportion of plot holders actually farm today:

Less than a half [ ]

About half of them (5 over 10) [ ]

More than two third of them (about 7 over 10) [ ]

Almost everyone (about 9 over 10) [ ]

How do you see the future and what are your prospects?

As a beneficiary of the scheme?

As a member of the community?

As a farmer in the scheme, has your situation improved over the last 2 years?

Why?

Final general comments the farmer would like to make:

Prospects

Current Situation

- Main assets opportunities strengths/ today or tomorrow?
- Main weaknesses and constraints/today or tomorrow?

Objectives

What do you think of your cash crops?

Perennial

Annual/seasonal crops

Other (livestock)

What about the prospective?

Means

- Do you have some capital to invest for future plans?
- Do you have land unused and available for further development?
- Do you have enough family labor?
- What is the cropping system having the best annual margin?
- What will be the annual margin produced by this farm within the next 10 years?
- How long does this farmer need to recover his initial investment on one of his farm?

Field survey and households interview

Main Canal in Gia Xuyen

Channel Level 2 in Gia Xuyen

Channel level 3 in Gia Xuyen

Hop Tien main canal

Hop Tien secondary canal

Hop Tien canal level 3

APPENDIX B – STATISTICAL TEST

Table B1: Different factors selected for testing PCA about livelihood diversification in Hop Tien and Gia Xuyen

Factors	Name	Measure unit	Annotation
1	Farmers' types	Ordinal	Hop Tien 1 = Type I (55 people) 2 = Type II (28 people) Gia Xuyen 1 = Type I (78 people) 2 = Type II (4 people) 3 = Type III (5 people)
2	Age of head farmer in the household	Nominal	
3	Education of head person in household	Ordinal	0 = Non education 1 = Primary level 2 = Secondary 3 = High School 4 = College/ University
4	Gender of head farmer in hh	Ordinal	1 = Male 2 = Female
5	Number of farm labor	Nominal (person)	
6	Number of people in each family	Nominal (people)	
7	Size of land holding	Nominal (ha)	

8	Expertise of farmer	Ordinal	0 = non farm expertise 1 = experimental year < 15 year 2 = (15-25 year) 3= (26-35 year) 4 = (> 35 year)
9	Intention for agricultural diversification	Ordinal	1 = very much 2 = Fair 3 = Not so much 4 = very little
10	Income sources of family	Ordinal	1 = only on farm income 2= on-farm income + non-farm income
11	Cropping system style	Ordinal	Hop Tien 1 = Only Rice 2 = Rice, Onion 3 = Rice, Water melon 4 = Rice, corn, squash, water melon 5 = Rice, corn, squash, water melon 6 = Rice, Potato, squash, onion 7 = Rice, squash, vegetable 8 = Rice, onion, squash Gia Xuyen 1 = Spring rice-Summer

			rice 2 = Spring rice-water melon-summer rice-potato 3 = Spring rice-water melon-winter vegetables 4 = Spring rice-soybean-special onion 5 = Spring rice-summer rice-winter vegetable
12	Different kind of livestock	Ordinal	Hop Tien 0 = None 1 = Pig 2 = Pig, chicken 3 = Pig, fish 4 = Chicken, goose 5 = Pig, cow Gia Xuyen 0 = None 1 = Pig 2 = Chicken 3 = Fish, Pig
12	Rice yield	Nominal (ton/ha)	
13	Location of farm in the system	Ordinal	1 = Head 2 = Middle 3 = Tail

14	Elevation of farm	Ordinal	1 = low elevation 2 = Medium 3 = High elevation

Table B2: Different factors for PCA analysis of cropping system styles

Factors	**Name**	**Measure unit**	**Annotation**
1	Total amount of seed used for one unit of land (kg/sao)	Nominal (kg/sao)	
2	Potassium used for 1 unit of rice land (kg/sao)	Nominal (kg/sao)	
3	Nitrogenous fertilizer used for 1 unit of rice land	Nominal (kg/sao)	
4	Phosphate used for 1 unit of rice land (kg/sao)	Nominal (kg/sao)	
5	Herbicide used for 1 unit of rice land (kg/sao)	Nominal (VND)	
6	Machine expenses for 1crop	Nominal (VND)	
7	Cropping system style	Ordinate	Hop Tien 1 = Only Rice 2 = Rice, Onion 3 = Rice, Water melon 4 = Rice, corn, squash, water melon 5 = Rice, corn, squash, water melon 6 = Rice, Potato, squash,

			onion 7 = Rice, squash, vegetable 8 = Rice, onion, squash Gia Xuyen 1 = Spring rice-Summer rice 2 = Spring rice-water melon-summer rice-potato 3 = Spring rice-water melon-winter vegetables 4 = Spring rice-soybean-special onion 5 = Spring rice-summer rice-winter vegetable
8	Area cultivated (ha)	Nominal (ha)	
9	Intention for crop diversification	Ordinal	1= improving much 2 = improving 3 = fair 4 = decreasing 5 = decreasing much
10	Location of Household in irrigation system	Ordinal	1= Head 2 = Middle 3 = Tail
11	Farmer's satisfaction with current situation of water distribution (time interval, quantity of water supply)	Ordinal	1= very much 2 = Fair 3 = not so much

			4 = very little
12	Market condition for product consumption	Ordinal	1= Convenient 2 = Fair 3 = Not convenient

Table B3. Principal component analysis to explain the diversification of cropping systems in Hop Tien

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.518
Bartlett's Test of Sphericity	Approx. Chi-Square	89.530
	df	66
	Sig.	.029

Rotated Component Matrix(a)

	Component				
	1	2	3	4	5
Cropping system styles	**.778**				
Machine expenses for 1crop	.701	.148			.164
Farmer's intention for crop diversification	-.270	**.702**		.133	
Area cultivated	.365	.599	.323		-.104
Herbicide used for 1 crop	.330	.558	-.168	-.261	.130
Farmer's satisfaction with current situation of water distribution			**.845**		
Market condition for product consumption		-.503	.593	-.174	
Phosphate used for 1 sao rice	-.135		.460	.429	.223
Potassium used for 1 sao rice	-.177	.107		**10.00**	
Total amount of seed per land density in spring season (kg/sao; 1 sao=360m2)	-.400			10.00	
Location of Household in				10.00	**.797**

irrigation system					
Nitrogenous fertilizer used for 1 sao rice				10.00	-.694

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a Rotation converged in 8 iterations.

Table B4. Principal component analysis to explain the diversification of cropping systems in Gia Xuyen

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.552
Bartlett's Test of Sphericity	Approx. Chi-Square	91.680
	df	66
	Sig.	.020

Rotated Component Matrix(a)

	Component				
	1	2	3	4	5
Cropping system style	**.816**			-.137	.141
Farmer's intention for crop diversification	-.720	-.104	-.188	.152	
Machine expenses for 1crop	.456	-.256	-.234	.302	
Location of Household in irrigation system		**.785**			.137
Market condition for product consumption	.497	.651			-.155
Total amount of seedling per land density in spring season (kg/sao; 1 sao=360m2)	.119	.263	**.785**		
Phosphate used for 1 sao rice	.301	-.239	.572	.217	.212
Nitrogenous fertilizer used for 1 sao rice	-.233	-.379	.558	-.170	
Herbicide used for 1 crop	-.162			**.748**	-.169
Area cultivated				-.681	-.100
Potassium used for 1 sao rice	.138			.194	**.793**

Farmer's satisfaction with current situation of water distribution (time interval, quantity of water supply)	-.120	.112		-.306	.693

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a Rotation converged in 7 iterations.

Table B5 One way ANOVA test to check the cropping system difference of parametric factor " Potassium used for one crop" between farmers' types in Hop Tien

Descriptives

Potassium used for 1 sao rice

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
type I1_1	3	5.333	.5774	.3333	3.899	6.768	5.0	6.0
Type I1_2	5	5.800	.8367	.3742	4.761	6.839	5.0	7.0
Type I3	6	5.167	.4082	.1667	4.738	5.595	5.0	6.0
Type I1_4	4	5.625	.4787	.2394	4.863	6.387	5.0	6.0
Type I2_1	5	6.800	1.0954	.4899	5.440	8.160	6.0	8.0
TypeI2_2	9	5.056	.3909	.1303	4.755	5.356	4.5	6.0
Type I2_3	12	5.292	.4502	.1300	5.006	5.578	5.0	6.0
Type I2_4	5	5.600	.5477	.2449	4.920	6.280	5.0	6.0
Type I2_5	6	5.917	.2041	.0833	5.702	6.131	5.5	6.0
Type II_1	13	5.500	.4564	.1266	5.224	5.776	5.0	6.0
Type II_2	15	5.600	.6325	.1633	5.250	5.950	5.0	7.0
Total	83	5.548	.6608	.0725	5.404	5.692	4.5	8.0

Multiple Comparisons

Dependent Variable: Potassium used for 1 sao rice
Tukey HSD

(I) Farmer's type	(J) Farmers' type	Mean difference (I-J)	Sig.
type I1_1	Type I1_2	-.4667	.987
	Type I3	.1667	1.000
	Type I1_4	-.2917	1.000
	Type I2_1	**-1.4667(*)**	.025
	TypeI2_2	.2778	1.000
	Type I2_3	.0417	1.000
	Type I2_4	-.2667	1.000
	Type I2_5	-.5833	.926
	Type II_1	-.1667	1.000
	Type II_2	-.2667	1.000
Type I1_2	type I1_1	.4667	.987
	Type I3	.6333	.740
	Type I1_4	.1750	1.000
	Type I2_1	-1.0000	.174
	TypeI2_2	.7444	.397
	Type I2_3	.5083	.831
	Type I2_4	.2000	1.000
	Type I2_5	-.1167	1.000
	Type II_1	.3000	.995
	Type II_2	.2000	1.000
Type I3	type I1_1	-.1667	1.000
	Type I1_2	-.6333	.740
	Type I1_4	-.4583	.972
	Type I2_1	**-1.6333(*)**	.000
	TypeI2_2	.1111	1.000
	Type I2_3	-.1250	1.000
	Type I2_4	-.4333	.970
	Type I2_5	-.7500	.438
	Type II_1	-.3333	.980
	Type II_2	-.4333	.879
Type I1_4	type I1_1	.2917	1.000
	Type I1_2	-.1750	1.000
	Type I3	.4583	.972
	Type I2_1	-1.1750	.086
	TypeI2_2	.5694	.838
	Type I2_3	.3333	.994
	Type I2_4	.0250	1.000
	Type I2_5	-.2917	.999
	Type II_1	.1250	1.000
	Type II_2	.0250	1.000
Type I2_1	type I1_1	**1.4667(*)**	.025
	Type I1_2	1.0000	.174
	Type I3	1.6333(*)	.000
	Type I1_4	1.1750	.086
	TypeI2_2	**1.7444(*)**	.000
	Type I2_3	**1.5083(*)**	.000

	Type I2_4	1.**2000**(*)	.043
	Type I2_5	.8833	.271
	Type II_1	**1.3000(*)**	.002
	Type II_2	**1.2000(*)**	.004
TypeI2_2	type I1_1	-.2778	1.000
	Type I1_2	-.7444	.397
	Type I3	-.1111	1.000
	Type I1_4	-.5694	.838
	Type I2_1	**-1.7444(*)**	.000
	Type I2_3	-.2361	.997
	Type I2_4	-.5444	.812
	Type I2_5	-.8611	.142
	Type II_1	-.4444	.762
	Type II_2	-.5444	.447
Type I2_3	type I1_1	-.0417	1.000
	Type I1_2	-.5083	.831
	Type I3	.1250	1.000
	Type I1_4	-.3333	.994
	Type I2_1	**-1.5083(*)**	.000
	TypeI2_2	.2361	.997
	Type I2_4	-.3083	.994
	Type I2_5	-.6250	.496
	Type II_1	-.2083	.997
	Type II_2	-.3083	.940
Type I2_4	type I1_1	.2667	1.000
	Type I1_2	-.2000	1.000
	Type I3	.4333	.970
	Type I1_4	-.0250	1.000
	Type I2_1	**-1.2000(*)**	.043
	TypeI2_2	.5444	.812
	Type I2_3	.3083	.994
	Type I2_5	-.3167	.997
	Type II_1	.1000	1.000
	Type II_2	.0000	1.000
Type I2_5	type I1_1	.5833	.926
	Type I1_2	.1167	1.000
	Type I3	.7500	.438
	Type I1_4	.2917	.999
	Type I2_1	-.8833	.271
	TypeI2_2	.8611	.142
	Type I2_3	.6250	.496
	Type I2_4	.3167	.997
	Type II_1	.4167	.914
	Type II_2	.3167	.984
Type II_1	type I1_1	.1667	1.000
	Type I1_2	-.3000	.995
	Type I3	.3333	.980
	Type I1_4	-.1250	1.000
	Type I2_1	**-1.3000(*)**	.002
	TypeI2_2	.4444	.762

	Type I2_3	.2083	.997
	Type I2_4	-.1000	1.000
	Type I2_5	-.4167	.914
	Type II_2	-.1000	1.000
Type II_2	type I1_1	.2667	1.000
	Type I1_2	-.2000	1.000
	Type I3	.4333	.879
	Type I1_4	-.0250	1.000
	Type I2_1	**-1.2000(*)**	.004
	TypeI2_2	.5444	.447
	Type I2_3	.3083	.940
	Type I2_4	.0000	1.000
	Type I2_5	-.3167	.984
	Type II_1	.1000	1.000

* The mean difference is significant at the .05 level.

Table B6. Kruskal-Wallis test to check the difference between non-parametric factors of farmers' types in Hop Tien

Test Statistics(a,b)

	Name of different crops	Farmer's intention for crop diversification	Farmer's satisfaction with current situation of water distribution	Location of Household in irrigation system
Chi-Square	9.831	9.818	32.452	6.433
df	10	10	10	10
Asymp. Sig.	.455	.457	.000	.778

a Kruskal Wallis Test

b Grouping Variable: Famer's type

Table B7 One way ANOVA test to check the difference of parametric factors between farmers' types in Gia Xuyen

Descriptives

Variables	Farmer' type	N	Mean	Std. Deviation	Min	Max
Total amount of seedling per land density in spring season (kg/sao; 1 sao=360m2)	Type I1	24	2.938	.2242	2.5	3.5
	Type I2	3	3.167	.2887	3.0	3.5
	Type I3	32	3.047	.1481	3.0	3.5
	Type I4	9	2.889	.2205	2.5	3.0
	Type I5	10	3.050	.2838	2.5	3.5
	Total	78	3.000	.2132	2.5	3.5
Herbicide used for 1 crop	Type I1	24	53541.67	24446.889	14000	120000
	Type I2	3	46666.67	23094.011	20000	60000
	Type I3	32	44812.50	21574.234	14000	80000
	Type I4	9	49444.44	21424.934	15000	80000
	Type I5	10	39000.00	22759.613	14000	80000
	Total	78	47358.97	22631.993	14000	120000
Potassium used for 1 sao rice	Type I1	24	5.65	.915	5	8
	Type I2	3	6.00	1.000	5	7
	Type I3	32	5.83	.981	5	8
	Type I4	9	5.39	.486	5	6
	Type I5	10	6.55	1.301	5	8
	Total	78	5.82	.993	5	8

Multiple Comparisons

Tukey HSD

Dependent variables	(I) Farmer's types	(J) Farmer's types	Mean difference (I-J)	Sig
Total amount of seedling per land density in spring season (kg/sao; 1 sao=360m2)	Type I1	Type I2	-.2292	.375
		Type I3	-.1094	.296
		Type I4	.0486	.974
		Type I5	-.1125	.600
	Type I2	Type I1	.2292	.375
		Type I3	.1198	.872

		Type I4	.2778	.269
		Type I5	.1167	.911
	Type I3	Type I1	.1094	.296
		Type I2	-.1198	.872
		Type I4	.1580	.264
		Type I5	-.0031	1.000
	Type I4	Type I1	-.0486	.974
		Type I2	-.2778	.269
		Type I3	-.1580	.264
		Type I5	-.1611	.442
	Type I5	Type I1	.1125	.600
		Type I2	-.1167	.911
		Type I3	.0031	1.000
		Type I4	.1611	.442
Herbicide used for 1 crop	Type I1	Type I2	6875.000	.988
		Type I3	8729.167	.614
		Type I4	4097.222	.990
		Type I5	14541.667	.439
	Type I2	Type I1	-6875.000	.988
		Type I3	1854.167	1.000
		Type I4	-2777.778	1.000
		Type I5	7666.667	.986
	Type I3	Type I1	-8729.167	.614
		Type I2	-1854.167	1.000
		Type I4	-4631.944	.983
		Type I5	5812.500	.954
	Type I4	Type I1	-4097.222	.990
		Type I2	2777.778	1.000
		Type I3	4631.944	.983
		Type I5	10444.444	.854
	Type I5	Type I1	-14541.667	.439
		Type I2	-7666.667	.986
		Type I3	-5812.500	.954
		Type I4	-10444.444	.854
Potassium used for 1 sao rice	Type I1	Type I2	-.354	.975
		Type I3	-.182	.956
		Type I4	.257	.960
		Type I5	-.904	.105
	Type I2	Type I1	.354	.975
		Type I3	.172	.998
		Type I4	.611	.877
		Type I5	-.550	.909
	Type I3	Type I1	.182	.956
		Type I2	-.172	.998
		Type I4	.439	.749
		Type I5	-.722	.248

	Type I4	Type I1	-.257	.960
		Type I2	-.611	.877
		Type I3	-.439	.749
		Type I5	-1.161	.078
	Type I5	Type I1	.904	.105
		Type I2	.550	.909
		Type I3	.722	.248
		Type I4	1.161	.078

Table B8. Kruskal-Wallis test to check the difference about non-parametric factors “between farmers’ types in Gia Xuyen

Test Statistics(a,b)

	Location of Household in irrigation system	Cropping system
Chi-Square	8.523	77.000
df	4	4
Asymp. Sig.	.074	.000

a Kruskal Wallis Test

b Grouping Variable: Farmer's type

APPENDIX C – SUPPLEMENTARY RESULTS OF OLYMPE